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Objects of Science Education in Underdeveloped Countries*

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IT may be useful, in this paper, to draw attention to the special needs of science education in underdeveloped countries which are characterised by an extremely low level of living, and widespread under-employment. The only way to improve the level of living is to increase the per capita production of goods and supply of services by an increasing use of machinery driven by steam or electricity as a substitute for human or animal labour. This can be done only through industrialisation in its broadest sense of manufactures, agriculture, transport and communications, distribution, etc.

Industrialisation would be possible only with the help of a rapidly increasing number of semi-skilled and skilled workers, technicians, engineers and technologists, physicians and scientists. A strong base of sicence education is indispensable for this purpose; this point is widely appreciated.

Industrialisation together with an expansion of both imports and exports (with an increasingly larger content of semi-manufactured or manufactured articles) would be possible only through the most effective utilization of domestic resources. To do this, it would be necessary to develop and expand technological and applied research. This point is also appreciated when it is realised that even the most advanced countries like the U.S.A. or the United Kingdom have to devote a third or more of their non-military research to improve the quality of products already in use to hold their position in a competitive world market.

To sustain an adequate base of technological and applied research, it is essential to establish and foster tradition of scientific research which would offer full scope for free communication and exchange of views and criticisms among research scientists. This can be achieved only through the promotion of pure or pioneering research†, because it is only the research scientists who can function as the eyes and ears of the nation in the field of science, and can foster the growth of the scientific tradition within the country and maintain contact with the progress of science abroad.

An important aim of science education must be to supply an increasing number

*Paper presented at the Commonwealth Conference on the Teaching of Science in Schools held at Peradiniya, Ceylon in December 1963.

†It is not possible for every country to take up research in all subjects. It is, however, necessary to encourage and provide facilities for pioneering or fundamental research on a small scale either within the country itself or in regional or international research centres. Fortunately, pioneering research can be and has usually been done on a small scale and at low expense; every country, however small, can therefore offer facilities for this type of research.

of qualified students for technical, technological and scientific institutions at all levels and for centres of both applied and fundamental research. This is essentially the utilitarian aspect of science education

There is also a deeper need which is the heart of the problem of 'modernisation' of the underdeveloped countries. The emergence of science during the last four hundred years, at first slowly and then at a rapidly increasing pace, is a turning point in the history of civilization. Before the emergence of science, there were only two broad domains of human decisions In one domain there was individual freedom of choice of food, clothes, recreations, etc., or of individual creative activities in art, literature, music, etc., within, of course, the limits permitted by society or of supplies and facilities available to the individuals concerned The other domain of all organised human activities was and must always be regulated by the 'principle of authority' in which sanction would depend on the status or level of the authority This is true in all primitive or present day communities all over the world, in organised churches and religions; in military, police or administrative systems; in public and private enterprises; and in law The decision of a law court may be upheld or reversed by a higher court of appeal; but the second decision also would be subject to confirmation or reversal by a higher court and so on. The decision of the highest court to which a case has been or can be referred must be accepted, but there is no guarantee that such a verdict would not have been reversed if an appeal to a higher court had been made or were possible. This principle of authority must be accepted for the very existence of society itself.

The same principle of authority must, however, be completely rejected in the field of science. Cause and effect have been the subject of enquiry from time immemorial but only in respect of events in isolation. That natural phenomenon is amenable to rational and unified explanation is the great break-through of the human intellect which occurred only with the emergence of science and is the characteristic mark of the modern age. Modern science consists of a patient accumulation of facts and observations and a critical study of their inter-relations based on the uniformity of nature which can be discovered by the human mind. Science thus introduced for the first time the concept or principle of objective validity which has its foundation in the nature itself and cannot be changed or upset by any human authority however high. The findings of the most eminent scientists are subject to critical check and corroboration or refutation by their youngest scientific colleagues. A single new observation may call for a more comprehensive theory. The older accumulated knowledge would still remain valid, and later discoveries must be integrated with the earlier knowledge.

Authority based on status is irrelevant to science. The transformation of all the advanced or the rapidly advancing countries has been brought about by the acceptance, slowly at first, and now in an increasing measure, of a scientific and rational view of life and nature. This is the foundation of the modern age.

In the underdeveloped countries the most urgent need is to establish and develop the outlook of science, and the experi-

mental attitude of mind to acquire knowledge of natural and social forces and to use such knowledge to invent new techniques for initiating material and social changes. This is the only way in which decisions can be made in an increasingly rational manner and in accordance with the principle of scientific or objective validity, based on relevant data and correct reasoning. This is the only way to replace superstition, out-date custom or dogma, and to bring about a change of society to make conditions suitable for rapid economic and national development by removing all barriers to the effective utilization of all productive forces and all available resources for the benefit of all the people of the country.

The advancement of science and the growth of the scientific and rational outlook is an essential condition for the modernisation of the less advanced countries. It is necessary for each country, however backward or small, to have as quickly as possible a sufficient number of men with a scientific outlook who would be able increasingly to influence the thinking of the nation and of persons who have the responsibility of making policy decisions at the national level. How to attract a sufficient number of persons in the field of science is thus the crucial problem of national and world development. This can be achieved only through an increasing appreciation of science and scientists by the general public.

The most fundamental aim of science education must be therefore to build up a community of scientific workers and to promote the social appreciation of science among the general public. It is therefore necessary to lay the foundations, with as wide a base as possible, for a country-wide system of school education oriented to science and at the same time to promote advanced studies of science and technology and research at the highest level.

School science must fit into the economic life of the general masses of the people and have its roots in the villages in underdeveloped countries. At higher levels, facilities must be provided for the training of technicians and technologists, and also of candidates of outstanding ability for admission to higher scientific and technological institutions.

It would be a fatal mistake to establish an expensive system of science education on the model of the advanced countries which would be beyond the means of the nation as a whole. It is necessary to evolve, through experimentation and research, a system which would be available in time for all the people on a country-wide basis, within the means of the nation.

The approach must be to use teaching aids which would be easily available or can be made available at a low cost all over the country. As most of the pupils will be living in villages, it would be advisable to use agriculture and rural industries as a general base for the teaching of science. The programme should consist largely of nature studies, observations, measurements and experiments which can be done with the help of simple articles, specimens, etc., which are locally available, or which can be constructed with local materials in the villages.

At the secondary stage, it would be necessary to introduce scientific instruments and equipment but these should be of the simplest types, preferably such

as can be manufactured within the country out of domestic resources.

At all levels, the main object would be to stimulate the spirit of enquiry, the desire to make observations and measurements or carry out experiment to find out something which is not known. It is essential to refrain from asking the students simply to acquire knowledge of facts or to perform set exercises in the form of practical work. In underdeveloped countries where the scientific tradition has not yet been established, such an approach would tend to make the students look upon science as something like magic or accept the facts on the basis of the authority of the teachers, and thus frustrate the real purpose of the teaching of science.

Our Units of Measurement—I

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INTRODUCTION

IN our study of science we are primarily concerned with the art of creating order out of chaos which is invariably met with during the process of observation of the various phenomena of Nature, accordingly, our most persistent intellectual efforts are directed towards the discovery of a certain well-knit pattern, design, system or structure of ideas and thoughts, in terms of which the elements of our experience with the physical world can be interpreted. Thus, as was nicely put by the famous British mathematician and philosopher A.N. Whitehead (1861-1947), 'to see what is general in what is particular and what is permanent in what is transitory is the major aim of all scientific endeavour.'

Now, the first and the foremost step necessary for the attainment of this cherished objective consists in making measurements on things. In fact, it is only through a rational analysis of the results of these measurements that we obtain a glimpse of the orderliness that governs the phenomenon under study. Quite naturally, the scientist strives to make his process of measurement more and more systematic and refined and his mode of analysis more and more thorough and rigorous. It so happens that in both these respects the science of physics is by far the most advanced of all sciences. To this extent, therefore, it may be looked upon as the basic science, indeed, a number of scientific disciplines which have emerged from time to time originally started as merely different branches of the mainstream of physics.

In physics again we can discern certain domains of activity which are intuitively more *basic than others, for instance, the* preliminary, and in some sense fundamental, study of the elements of space, time and matter. The most basic measurements the student of physics has to deal with are the ones related to these three entities of Nature; these measurements, in principle, constitute the elementary processes of determining (i) the *length* of a straight line joining two given points of space, (ii) the *time interval* elapsed between two given instants of time, and (iii) the *mass* of a given piece of matter. In order to state these measures numerically, we ought to define the respective *units of measurement*, in terms of which the results of an actual process of measurement could be expressed. And, in order that the results so stated be both unambiguous and free from personal factors, the units employed must be such as are quite faithfully reproducible and quite universal in character. It is indeed a matter of genuine satisfaction that, through centuries of experimentation and contemplation, these requirements have now been met to a really remarkable degree of accuracy. To narrate the exciting and thrilling story of these attainments, dominated by the

flavour of an ever-increasing degree of scientific precision, is the central theme of the present series of articles

In the first two instalments of the series, viz., I & II, our discussion will largely confine itself to the aforementioned three *fundamental* units. Noting that certain suitable combinations of these units enable one to define any of the so-called derived units of mechanics—the subject dealing with the motion, in space and time, of matter— the discussion of these two parts may be regarded as practically complete insofar as the mechanical quantities are concerned. The consideration of the non-mechanical quantities, however, necessitates the introduction of a few more fundamental units of measurement; these will form the subject-matter of the remaining part of the series.

Emergence of the Unit of Length
(Historical Background)

About five thousand years ago, in the great river valleys of Egypt and Mesopotamia (the latter now approximating to the state of Iraq), the royal surveyors were already mapping their masters' fields, while the royal architects were planning the temples, palaces and tombs. These activities led to the development of practical geometry into a serviceable body of rules, characterised by a secure tradition and a great uniformity of practice. Over a score of centuries the master builders of Egypt were employing a unit of length, namely the *cubit*—defined by the distance from the elbow to the tip of the middle finger—which, in actual practice, did not vary by much more than 1 part in 200 from the mean! Later on, with a view to regulating all measurements on the rise and fall of the waters of the Nile, a standard cubit was kept in the capital in priestly custody, besides this, there was marked, by official decree, the unit *schoenus*, an itinerary standard of 12,000 cubits, on the road from Memphis to Faium. This bespeaks very admirably the great attention these people paid to the preservation of a common linear standard.

Nearly a thousand miles away from the site of the Egyptian civilization, i.e in Mesopotamia, during much the same period, essentially the same standard of length—the cubit—was maintained, with almost equal exactitude. Interestingly enough, the mention of this very unit of length is made in the '*Ślokas* of some of the early Indian writings as well, here, it appears by the name *hasta*, implying precisely the same definition as adopted in the other two civilizations. This was possibilty the most handy of all the units one could imagine

With the decline of these practical-minded civilizations, there arose, in the first millennium B.C., the famous civilization of the Greeks One of the many influences this civilization had on the course of scientific development was the replacement of the hitherto practical geometry by the new abstract geometry, which originated in the genius of the first individual scientist the world has ever known, namely Thales of Miletus (c 624-547 B.C.), received successive additions and refinements from men like Pythagoras (c. 572-497 B.C.) and Eudoxus (c. 408-355 B.C.), and got brilliantly systematised by the great teacher Euclid (c. 330-275 B.C.). The resulting concept of the abstract space, namely the Euclidean space, to which the actual space of our physical experience so closely approxi-

mates, was thereby accepted as providing a highly workable spatial frame-work of physics

Based as it was on a set of highly plausible definitions, axioms and postulates, the Euclidean geometry, by virtue of its rich treasure of theorems and corollaries, put the subject of length measurement on a sound theoretical basis. One could now picture quite unambiguously as to how to estimate, at least in principle, any given length in terms of an arbitrary unit of length (adopted for the purpose of measurement) and its sub-multiples, to within any specified residual uncertainty. The numerical result could, in general, be expressed in any agreed system of arithmetical fractions. It may be of interest to mention that the system of fractions that was in vogue in the times of Euclid and practically remained so, in Europe, until about the early parts of the 17th century was the one based on sexagesimal fractions (with the base 60, which almost certainly was of a Sumerian-Babylonian origin, dating back to about 1700 B.C.). This system of arithmetical expression, along with the others such as the Roman system, got universally replaced by the illustrious decimal system (with Arabic numerals) which, in all essentials, was developed by the Hindu mathematicians of the Vedic period (1500-750 B.C.), was carried over to the West through the intermediary of the Arabs (in the beginnings of the second millennium A.D.) and introduced into the European learning through the advocacy of the Dutch mathematician Simon Stevinus (1548-1620) and the English mathematician Henry Briggs (1556-1630). At present, this is practically the only system of notation one has to speak about.

Having developed the logical methods of comparing lengths and expressing them in numbers in a suitable arithmetical notation, the major problem of practice consisted in selecting an appropriate unit and preserving it in the form of a material standard. Reference has already been made to the cubit and to the official preservation of the corresponding standard in charge of the priests. Besides, a number of other units, either derived from the cubit or defined independently, also came into practical use. With the advent of the Scientific Renaissance in Europe, in about the 17th century, the regions of scientific activity started spreading over a larger and larger number of countries over the continent. Along with that, there came into adoption a still larger variety of units of length measurement. These were due primarily to the lack of fast communication and also due to the lack of realisation of the desirability of having a certain uniformity of units, varying from state to state and even from town to town. Any detailed description of this bewildering variety of units, both of weights and measures, would make our account here unnecessarily long. Suffice it to say that in the eighteenth century France, with the largest population in Europe and engaged mainly in agriculture and domestic industries, the situation was chaotic. And the same was true of almost any other country of Europe, but for England where a strong central government and mercantile development had imposed and maintained a uniform system of weights and measures at least from the time of Edward III (1327-1377). The sub-divisions of the British standards, however, have been, and still are, at variance with the decimal system, [illegible]

ingly, these standards have been found rather unfit for universal adoption. We shall, therefore, skip over the history of establishment of these standards and pass on to the consideration of their French counterparts.

ADMITTANCE OF THE METRIC SYSTEM

The first effective step towards the formulation and establishment of a national system of weights and measures *in decimal notation* was taken in France, within a year of the outbreak of the Revolution in 1789. In accordance with the aims of the Revolution, and also in line with the scientific spirit of universality, it was intended to base the fundamental units of measurement on certain natural standards—common to all men.

Among the academicians of the land, suggestions had already been made from time to time about basing a new and standard system of measurements on some suitable physical constants. In regard to the unit of length measurement, for instance, the astronomer Jean Picard (1620-1682) suggested as early as 1671 'the length of a pendulum beating seconds, i.e. having a time period of two seconds' as the requisite standard, although he seems to have rightly suspected that this length would vary with latitude. In 1748, the mathematician Charles-Marie de la Condamine (1701-1774) recommended 'the length of a seconds-pendulum *at the equator*' as the desired standard. On May 8, 1790, the National Assembly decreed that the Academy explore the possibility of adopting this standard as the national, or even the universal, unit of length measurement. In this decree, however, there was no mention of the decimal notation.

In the Academy, however, matters went differently. The academicians decided to investigate side by side a different, but all-the-more fascinating, suggestion, first put forward by the astronomer Jacques Cassini (1677-1756) in 1720, namely that a suitable fraction of the meridian between the terrestrial pole and the equator be taken as the required standard. The question of an accurate practical measurement of the meridian was indeed very difficult, but the academicians had already taken keen interest in this problem from the point of view of 'the figure of the Earth', that is, whether it was flattened or elongated towards the poles. They regarded this problem almost their own and hence preferred to make use of a part of the funds made available by the Assembly in the investigation of this leading scientific problem. As Biot (1774-1862) wrote a few years later, 'science also has its politics'.

It was the Commission appointed for going into the relative merits of these two rival suggestions that recommended on October 27, 1790, the use of decimal notation in the new system. Later, on March 19, 1791, they recommended that the measurement of an arc of the meridian would be preferable to the use of the seconds-pendulum—for the main reason that the latter definition involved the unit of time and hence undermined the necessity of defining the fundamental units of measurement independently of one another. From the measurement of an arc of the meridian, on the other hand, if one were to derive the length of a quarter of the Earth's meridian (in terms of any arbitrary unit of length), *one ten-millionth part of which*—later denominated as the *metre* (whence the system itself derives

the name—the *metric* system)—*would be taken as the unit of length measurement*. The National Assembly adopted these recommendations on March 26, 1791.

In 1792, active work commenced on this project, namely the measurement of the length of the meridional arc between Dunkirk (France) and Barcelona (Spain). The pace of progress, however, was quite slow. Impatience with the slow progress of the work and urgency of the need of a standard led the National Convention (which had by then replaced the Legislative Assembly) to adopt, in September 1793, a *provisional* metre, based on the earlier measurements of the Paris meridian by the astronomer Nicolas-Louis de Lacaille (1713-1762). Material standards were to be prepared under the supervision of the Academy and sent to all local administrations throughout France. Corresponding changes were to be incorporated in the school textbooks of arithmetic and the use of the new unit was to become obligatory with effect from July 1, 1794.

Political events, however, took a new turn. On August 8, 1793, the Academy of Sciences and all other learned societies were suppressed by the order of the Convention. A number of leading academicians were dismissed on flimsy grounds and, consequently, work on all scientific projects was seriously hampered. It could restart effectively only when the *Institute National* was established as successor to the suppressed Academy. The geodetic work, begun in 1792, got completed only towards the end of 1798; this enabled the replacement of the provisional metre of 1793 by a more dependable one, the latter being approximately 0.3 mm shorter. The corresponding platinum end-standard, of cross-section 25.3×4 mm was constructed and adjusted by Janety so that its end-to-end length at 0°C was equal, as near as possible, to the metre deriving from the measured terrestrial meridian, and on June 22, 1799, it was deposited, with full diplomatic and legislative ceremony, in the National Archives. The new standard, named *Mètre des Archives*, along with its decimal sub-multiples, was approved as legal on December 10, 1799, becoming compulsory in 1801. In practice, however, the adoption was rather slow and as late as 1837 the French Government had to pass a law forbidding, under severe penalties, the use of the old units as from the New Year's day of 1840.

By 1872, seven other European states and a good part of South America had adopted the new system. Great Britain legalized its *optional* use in [illegible] and is, at present, considering the question of its full-fledged adoption. We in India have also recently admitted it into use by the rule of law.

ESTABLISHMENT OF THE INTERNATIONAL PROTOTYPE METRE

Shortly after the adoption of the Mètre des Archives, the investigators who had worked on the geodetic measurements prepared a fresh and detailed analysis of their findings and arrived at the conclusion that the metre adopted by the [illegible] commission was rather too short. Instead of expressing their results in [illegible] terms, it appears more appropriate to indicate, in relation to the [illegible] of the ten-millionth part of a terrestrial quadrant, that the adopted metre was about 0.2 mm, i.e., 1 part in [illegible], shorter than the intended one, the earlier provisional one thus being about [illegible] mm in excess of the intended. The

the fundamental unit of length was ultimately arbitrary!

A closer reflection at the problem, however, readily reveals the hollowness of the doctrine that the fundamental units *must* be derived from certain universal sources. It is obvious that, irrespective of the mode of definition and the source of derivation, any specified unit is, in the last analysis, bound to be arbitrary In fact, the only serious consideration that need be given to the problem of the units is the one in regard to the possibility of their *faithful and unambiguous reproduction* (of course, under a suitably laid down set of physical conditions) Accordingly, the fiction of a certain pre-assigned relationship between the fundamental standard of length and the earth-quadrant has got to be quietly forgotten

In the sixties of the last century, as the popularity of the decimal metric system began spreading from state to state, suggestions started pouring in that *new* metric standards (of length and mass) be prepared and their official copies constructed and distributed to the various organisations. The French Government thereupon took necessary steps in this direction, as a result, there came into creation, in 1875, the *Bureau International des Poids et Measures* (BIPM)—the International Bureau of Weights and Measures—comprising a central laboratory and office located at Sévres, near Paris. The work of the BIPM (which now includes the fundamental metrology of temperature, photometry, electricity and the ionizing radiations) is managed by an International Committee of Weights and Measures, meeting every two years, which is elected by, and under the authority of, the General Conference of Weights and Measures, meeting every six years. The membership of the General Conference now extends over about forty states.

The International Committee resolved that, in order to maintain the continuity of use, the new standard of length be defined as equal to the Mètre des Archives and, from the point of view of satisfactory preservation, it be reconstructed from an alloy of 90 per cent platinum and 10 per cent iridium, which, for its metrological qualities, had already been studied by the physicist Fizeau (1819-1896) and the chemist Deville (1818-1881). Instead of making the new standard of the end-type, it was considered preferable to make it line-type, by casting it in the form of a bar, of a special cross-section

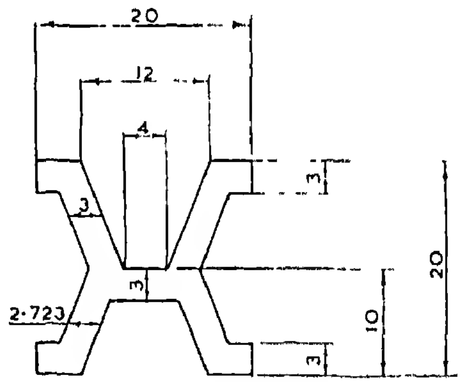

Fig 1. Cross-section designed by Tresca for the former International Prototype Metre and the national copies (dimensions in mm) (after Barrell)

shown in Fig. 1 (so designed by the engineer-metallurgist Tresca (1814-1885) as to give it maximum rigidity for a given quantity of the precious alloy used and also to ensure that the plane surface exposed in the upper channel of the bar was a part of the neutral surface when the bar sagged on its supports), the bar bea-

ring on its exposed neutral plane two parallel defining lines, separated at, 0°C, by the distance equal to the unit metre length as represented by the Métre des Archives. The neutral plane of the bar is clearly the most suitable of all planes because the distance between the lines engraved thereon is least influenced by the manner of supporting the bar. Nevertheless, it was also specified that the bar be symmetrically supported on two rollers at right angles to its length and 0.571 metre apart (for a bar of total length about 101.6 cm); with this specification, the actual distance between the defining lines would be least sensitive to the separation between the rollers—which is again important from the reproducibility point of view.

Because of the difficulties in the metallurgy of the specified alloy, actual work of construction of the new standards could not make a satisfactory headway until the late eighties. The specimen finally accepted was the one now known as the Johnson-Matthey alloy, containing 89.75–90.25 per cent of platinum and 9.75–10.25 per cent of iridium, with small tolerances for impurities such as ruthenium, rhodium, palladium, copper, silver, gold and other elements. A number of metre copies were made of this alloy and were ready for distribution when the first General Conference met in Paris in September 1889. One of these copies was denominated as the *International Prototype Metre*, superseding the Métre des Archives, the length of the former having been declared as equal to that of the latter (within the limits of experimental error, namely about 1 μm$=10^{-6}$m) and was kept at the headquarters of the BIPM at Sévres. Official copies, with certified lengths, given in terms of the metre represented on the Prototype, were distributed among the member-states.

The refined definition of the metre, adopted later by the 7th General Conference in 1927, reads as follows:

> The unit of length is the Metre, defined by the distance, at 0°C, between the axes of two transverse lines engraved on the platinum-iridium bar kept at the International Bureau of Weights and Measures and declared to be the Prototype of the Metre by the First General Conference of Weights and Measures, this bar being kept at the normal atmospheric pressure and supported by two rollers of mean diameter one centimetre placed symmetrically in the same horizontal plane and a distance of 571 mm apart.

We notice that the definition of the metre requires the bar to be at the naturally fixed temperature of melting ice. In practice, however, it is not always convenient to make comparisons at 0°C, even of the primary standards in the laboratory; rather, for everyday use lengths must be standardised at normal working temperatures. It thus follows that a knowledge of the coefficients of thermal expansion of these bars is required; accordingly, much effort has been put into determining the thermal dilatations of metals used for constructing the length standards, and particularly of the platinum-iridium alloy.

Next, it is interesting and important to have an idea of the degree of precision attained in the comparison of the various metre bars and the degree of constancy with which the fundamental unit has been maintained since its inception in

1889. The difference between two metre-standards provided with modern defining lines can be determined with an uncertainty not exceeding 0.1 μm. Such a precision cannot possibly be guaranteed for the whole family of metric bars as ruled in 1889 because of the general lower quality of the lines engraved at that time in comparison with the modern rulings, indeed, many of the original copies have, during the past few years, been re-ruled Nevertheless, it can be safely said that the International Prototype and its copies have preserved the unit metre distance with a precision of about 0.2 μm i.e. 2 parts in 10^7.

THE OPTICAL METRE

Although the International Prototype Metre and its official copies did preserve the fundamental unit of length quite adequately, the problem of reproducing the metre quickly and correctly still remained largely unsolved. It appeared, no doubt, highly desirable to evolve an alternative definition, which could enable one to realise the metre in any reasonably equipped scientific laboratory *without recourse to the reference bars preserved at a limited number of stations*. One therefore notes with a sense of innate satisfaction that, as a result of the high precision work carried out in the field of atomic spectroscopy during the present century, the metre has finally been defined through an atomic standard which gives it an accuracy of about 1 part in 10^8 in the matter of reproducibility. Incidentally, then, one of the major objects of the French reform, namely the use of an invariable universal natural standard for a physical unit, has at last been achieved, the arbitrariness of the definition is, of course, bound to remain.

This part of the story again starts with a Frenchman, the physicist Babinet (1794-1872) who for the first time drew attention, in 1829, towards the concept of employing the wavelength of some suitable light-wave as a standard of length. In 1889, the American physicist Michelson (1852-1931) and his famous collaborator, the chemist Morley (1838-1923), published a paper 'On the feasibility of establishing a light-wave as the ultimate standard of length', in which they described as to how one could employ the now well-known Michelson interferometer in order to determine the number of wavelengths contained in a metre.

The practical work in this direction started at the BIPM during 1892-93, when the first direct measurement of the metre in terms of the wavelength of the red light of cadmium was made by Michelson and Benoit. In 1905-06, Benoit, Fabry and Perot improved upon the accuracy of this measurement and announced that this wavelength is, within the limits of experimental error, 6438 4696×10^{-10} m in standard air; the reader may keep in mind that the modern specification of standard air for spectroscopy and metrology is: dry air, at 15°C, under a pressure of 1013250 dynes/cm^2 and containing 0.03 per cent by volume of carbon dioxide. In 1907, the International Solar Union (now the International Astronomical Union) adopted the wavelength of cadmium red line as the reference basis for all spectroscopic measurements of wavelengths and defined its value in terms of the International angstrom (A) as *exactly* 6438.4696 A, the unit A thus being provisionally equal to 10^{-10} m but subject to minor possible changes consequent upon any later improvement in the experimental value

of the wavelength in question. The 7th General Conference, meeting in 1927, although rejecting a proposal to adopt the cadmium standard as the ultimate reference for the metre, gave formal sanction to determinations of length being based on the value of $\lambda_R = 6438.4696 \times 10^{-10}$ m as an *alternative* to the use of the material standards. Incidentally, this implied that from now onward the angstrom unit would, by definition, be exactly equal to 10^{-10} m.

In pursuance of the foregoing sanction a number of physical laboratories all over the world carried out fresh determinations of the number of wavelengths, in standard air, of cadmium red line contained in the metre. The weighted mean value, derived by Barrell in 1948 from nine determinations made by various investigators during the period 1892-1940, is 1553164.12, the corresponding value of λ_R being the same as adopted above, with a standard error of about 6 parts in 10^8. In a recent re-evaluation of the data, Hart and Baird (1961) derived a value of $6440.2490 \times 10^{-10}$m *in vacuo*, corresponding to the value $6438.4695 \times 10^{-10}$ m in standard air of refractive index 1.000276381. This revision, fortunately, has not created any new difficulty of practice.

Now the question arises as to what it was that still came in the way of defining the metre *exclusively* in terms of a wavelength standard, thus superseding the material standard altogether. The answer is that no known optical radiation, emitted from a natural element such as cadmium, appeared to possess a significantly higher reproducibility than the best material standards. Lately, however, this did become possible, due mainly to the introduction and development of improved sources of monochromatic light employing, instead of the natural elements, pure isotopes and those too of even atomic charge and mass and hence of zero nuclear spin. This replacement results in much finer lines of emission, enabling an improvement by [illegible] of *magnitude* in the degree of reproducibility.

The three rival claimants for the unique honour in sight, as indicated by the 9th General Conference in 1948, were the red line of the cadmium isotope $_{48}Cd^{114}$, the green line of the mercury isotope $_{80}Hg^{198}$ and the orange line of the krypton isotope $_{36}Kr^{86}$. A comparative study of these three lines carried out quite intensively and extensively during the period [illegible] clearly indicated that the krypton line [illegible] represents the most dependable basis for an optical definition of the metre.

Basing its deliberations on the [illegible] concordant results coming from the leading laboratories of the world, the 11th General Conference, on the 14th of October 1960, adopted the following resolution:

1. The metre is equal in length to 1650763.73 wavelengths in vacuo of the radiation corresponding to the transition between the levels $2p_{10}$ and the $5d_5$ level of the Kr^{86} atom.
2. The definition of the metre in force since 1889, based on the International Prototype Metre made of platinum-iridium, stands repealed.
3. The International Prototype of the metre, adopted by the 1st General Conference of Weights and Measures of 1889, would be preserved at the International Bureau of Weights and Measures

under the same conditions as were laid down for it in 1889.

The source of the standard radiation, recommended in 1960 by the International Committee, is the Engelhard lamp, operated according to the following instructions:

"In conformity with the paragraph 1 of the (foregoing) resolution, adopted by the 11th General Conference of Weights and Measures (October, 1960), the International Committee of Weights and Measures recommends that the Kr^{86} radiation adopted as the fundamental standard of length should be realized by means of a hot cathode discharge lamp containing krypton 86 of purity not less than 99 per cent, in sufficient quantity to ensure the presence of solid krypton at the temperature of 64°K, this lamp being provided with a capillary having the following characteristics: internal diameter 2 to 4 millimetres, thickness of the walls about 1 millimetre.

"It is estimated that the wavelength of the radiation emitted by the positive column (of this lamp) would be uniform to within 1 part in 10^8 of the wavelength corresponding to the transition between the unperturbed levels, when the following conditions are satisfied:

"1 The capillary is seen through from such an end that the bright rays coming from the side of the cathode towards the anode are made use of.

"2. The lower part of the lamp, including the capillary, is immersed in a cold bath maintained at the temperature of the triple point of nitrogen to within a degree.

"3. The current density in the capillary is 0.3 ± 0.1 ampere per square centimetre."

Shortly afterwards, in 1961, Hart and Baird reported measurements, in terms of the new definition, made in the laboratories of the National Research Council, Ottawa (Canada), on four 1-metre line standards whose relationships with the former Prototype Metre were already well known. They found that the number of the standard wavelengths contained in the original metre averaged at 1650764.08, so that the new optical metre was shorter than the original one by about one-third of a wavelength, in more familiar terms, one could say that the new metre minus the old metre is equal to 0.20 ± 0.04 μm.

It is important to note that the length difference between the new and the old standards, if at all real, does not present any specific difficulties of continuity because it happens to be of the same order of magnitude as the uncertainty appearing in the preservation of the metre on a material standard and in the intercomparison of the various copies thereof. On the other hand, the new metre, unlike the old one, can be reproduced, if the stated physical conditions are guaranteed, with an accuracy of about 1 part in 10^8.

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A Formula in Optics Critically Examined

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WHAT is the number of images when an object is placed in between two mirrors inclined at an angle a? This was the question put to me by one of my students and to be very frank I was not able to answer it satisfactorily even after consulting books on the subject.

The problem may not be of great value to the great scientists but for a teacher like me nothing can be more important than guiding the students on the right path. I, therefore took the problem earnestly, and after having worked on the problem for sometime I have come to the conclusion that the formula for the number of images $n = \frac{360}{a} - 1$, given almost in all the books I consulted, is not valid for all values of a. It is only true for those values of a for which 360 is even times divisible by a. Invalidity of the formula is not very difficult to be proved.

My aim is not only to prove the above formula invalid but also to establish new laws for answering the above question. For this it will be better to deal separately with the following three cases which in their general form include all the angles from 0° to 360°.

Case I : The remainder of $180 \div a$ being equal to $\frac{a}{2}$ or $\frac{360}{a}$ an odd number.

Let the angle a between two mirrors OA and OB be 120° and an object P be placed in a position as shown in Fig. 1. OP is making an angle of 35° with OA

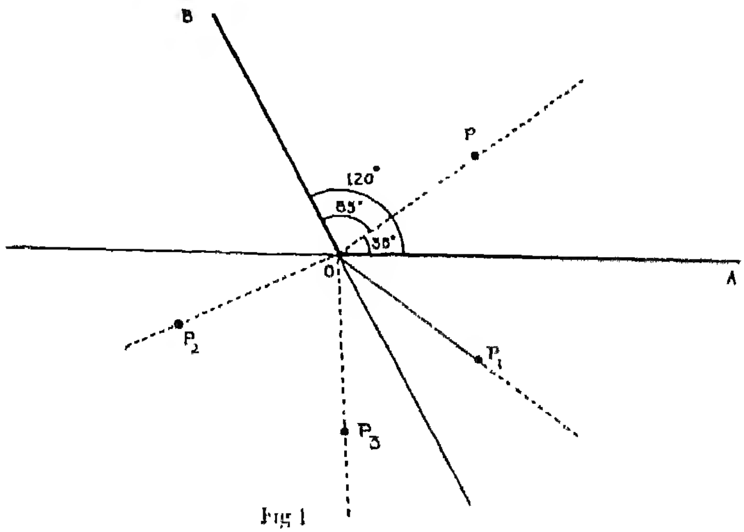

Fig 1

All About Noses

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THE nose is a characteristically human feature, mainly a decorative organ on our faces. Its absence or even a deformity will be quite pungent and, therefore, its external form is important. We must admit that in man there is no obvious connection between the form of nose and its function. Can we say anything about the relation of temperamental peculiarities to the form of nose ? Aristotle says that persons with thick bulbous nose are insensitive and swinish; that sharp tipped noses belong to irascible persons; large, rounded, obtuse noses are found in magnanimous, lion-like individuals; hooked eagle-like noses in the noble but grasping persons. But probably no such relationship exists. The nose in man shows many variations of form apparently due to some sort of degenerative flamboyancy in an organ. Perhaps sexual selection has played some part in the evolution of various nasal forms, but this seems hardly likely in view of the extreme commonness of all kinds of noses.

The nose is primarily concerned with smell which together with the taste forms a part of the same sense. Taste informs the brain about the suitability of a thing in the mouth. By smell we get more information about things near about (may be hidden from view), for instance, when buying apples or melons we usually rely on the odour. Inside the kitchen cooking things are mostly verified by the nose when one does not wish to taste, though the eyes may be the first indicator. Our sense of smell is not good, as also is the case with monkeys and apes. These are known to touch objects first, then take them for visual examination, then smell and finally taste them.

In a number of lower grades of animals like frogs and lizards, a passage between the nasal chamber and the roof of the mouth samples, by smelling, things that have been taken into the mouth. In fishes the smelling apparatus consists of two small capsules, one on each side of the head, from which nostrils open and a groove connects with the mouth cavity.

Two other important functions are performed by the nose; firstly, it removes impurities from the air, kills harmful bacteria before they reach the lungs and secondly warms the in-going cool air. In higher grades of animals delicate bony scrolls known as turbinals form an elaborate system which warms up the air as it passes through its channels. This is best developed in the Pacific ocean dweller, the otter where the turbinals form a very close mesh-work looking like a sponge. Usually two sets are present; the ethmoturbinals grow out from a median bony septum in the nose and the maxilloturbinals from the upper jaw. It is largely over the first set that the nerves for the reception of odours are distributed while the second set warms the air. In cats

1. Tapir
2. Wart hog.
3 Hippopotomus.
4 Elephant.
5. Ant-eater.
6. Aard-vark.
7. Star-nosed mole.
8. Star-nose.

where the ethmoturbinals are small, the sense of smell is poor while an exactly opposite condition occurs in dogs. The keen sense of smell which is probably the best in them have made them very useful in tracking thieves. At the other end of the scale are animals with little or no sense of perception like bull-dogs and Japanese spaniels. These could not survive if man had not been taking care of them from respiratory diseases. Squirrels are supposed to find their favourite nuts by scent and many animals will swim across a lake or river led by the odour of an edible stuff.

Many races put on various kinds of decorations by tattooing or painting on their noses. Some African races wear jewellery made of ivory, bone or wood by piercing the septum of the nose. In India, a Hindu woman will usually have her nose holed for wearing a gold ring or a bud.

In various animals the nasal region (everything in front of the eyes) of the head is patterned for different purposes. In elephants the trunk compensates for all the handicaps due to its bulky stature and short neck. Without moving and bending he can pull down branches from a tree, shower himself with water or dust, feel the air in all directions, convey things to his mouth, trumpet to its heart's content and use it as an effective weapon of offense and defence. The elephant's trunk is, in fact, nature's best nose and to its possesser a priceless treasure. In anteaters, the nose is in the form of a long tube and within lies an extremely long, mobile and sticky tongue which is used in catching ants on which the animals feed. Pigs and aard-varks which throw up mud and garbage in quest of delica- [illegible] A [illegible] required on the [illegible] elaborate [illegible] beneath [illegible] of [illegible] plish something that [illegible] for us to achieve [illegible] drill. The [illegible] whale [illegible] spermaceti oil which [illegible] the animal to balance in water.

The strangest of all [illegible] is found in the case of the star-nosed mole which has a circle of twenty-two fleshy little lobes giving it immense advantage in probing the soil for worms. A leaf-like [illegible] nose is present in the leaf-nosed bats with delicate foldings of the naked skin about their noses beset with fine nerve endings which pick up vibrations in the air caused by insect wings or even by the echoes of the air waves by bats themselves. In several desert living animals the nose is subjected to unpleasant blasts of sand and dust and is, therefore, provided with sphincter muscles which can close them.

The position of the nostril is extremely important in lung breathers living in water like hippopotami, crocodiles, frogs and whales. They have the openings so located that these parts emerge first from the water, the rest of the body remaining hidden beneath the water.

In most mammals long stiff hairs (vibrissae) that telegraph touch impulses to the body are present around the nostrils. Nocturnal (moving during night time) animals like rabbits, mice and cats use these whiskers to know objects they do not see and the walrus in raking the muddy ocean floor to find out edible clams.

Space Biology

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THE twentieth century has been designated by some as the 'space age'. Man's age-old desire to go to the outer world was realized when on April 12, 1961, the Russians launched the space ship, Vostok I piloted by Major Yuri Gagarin (Fig 1) Following him a number of Russian and American cosmonauts including a woman have orbited around the earth in space. This marvellous achievement is the result of teamwork and co-operation between large groups of scientists including biologists. While the role of an engineer or a physicist is perhaps very obvious to you, you might well wonder as to what is the contribution of the biologist in man's adventure into space. Living on earth, we hardly realize how much we are conditioned by the physical forces (like gravitation, atmospheric pressure, temperature, etc.) operating on us. Out in the space the conditions are so different that even the most ordinary activities like drinking water from a tumbler become impossible to perform (Fig. 2). The tremendous speed at which a rocket is shot would cause horrifying sensations and a paralysis of the mental activities of any one who boards this rocket. The science of space biology and space medicine arose from the need to study and seek solutions to the problems of man's survival in this environment.

Fig. 1 Major Yuri Gagarin, the first Cosmonaut.
(*Courtesy, Soviet Information Service*)

Space exploration has also given an opportunity to biologists, who unlike physicists or chemists are normally concerned with the phenomena on earth, to find out whether life exists outside the earth. Should any be discovered, the biologists' first wish would be to gain an

Fig. 2. This is how Valentina Tereshkova, the first space woman takes her food in space.
(*Courtesy Tass*)

understanding of the chemical basis of this life. Does it, like life on earth, use the protein-nucleic acid system ? If not, what chemical systems are used for heredity, storage and catalysis? Along with the search for life there is also the need for a clearer understanding of the chemical evolution which led to the origin of life on earth Before going further with the biology of space travel, however, let us first learn something about what constitutes space.

The Nature of Space

About and above us, surrounding the earth, is the atmosphere (Fig. 3). Scientists believe that it extends outward for about

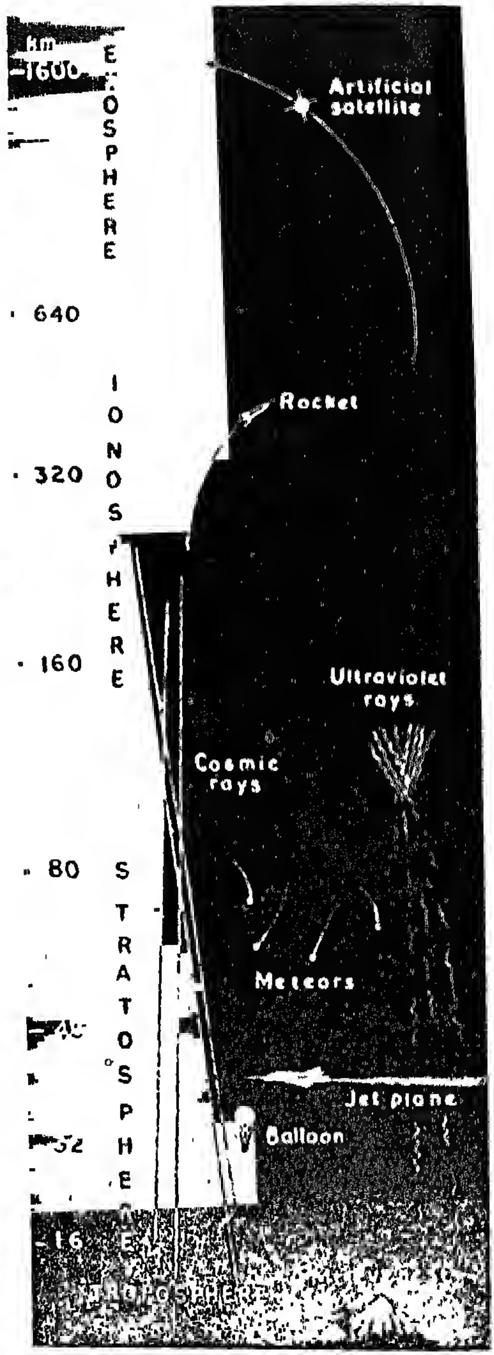

Fig. 3. Different layers of the earth's atmosphere.

960 kilometres or more. The lowest region extending to about 11 kilometres, is the troposphere. Only the first four miles are inhabited by living organisms. Several gases, water vapour and dust are rather tightly packed in this region. It is the weight of the molecules of all these substances that produces a pressure of approximately 10333 kilogrammes per square metre on our bodies at sea level. As we go up, the pressure falls 25 millimetres for every 274 metres and the pressure on our bodies also decreases accordingly. The temperature of the lower part surrounding us varies between 10°C to 40°C. In the upper part of the troposphere, however, it may be as low as -20°C.

Above the troposphere, for about 80 kilometres, lies the stratosphere. Here the molecules are few and sparse. At about 40 kilometres above sea level, there is a layer of ozone, very important to us because it filters out most of the ultraviolet radiation from the sun. Though such radiation is beneficial to life, in excess it may be injurious. The temperature in the stratosphere varies from −20°C to +90°C.

Extending outward from the stratosphere to a height of about 960 kilometres from the earth is the highly electrified ionosphere. This region has a still lower concentration of molecules. Here the temperature is as high as 1000°C.

Beyond the ionosphere is the outer space which is practically a vacuum.

The Biology of Space Travel

The conditions prevailing in space, i.e. above an altitude of 960 kilometres are extremely hostile to human life (Fig. 4). Pressure is so low, that the fluids of the body begin to vapourize; and there is no air to breathe. There is also no light because the atmosphere which scatters light rays does not exist. There is only a blazing glare from the sun; all else is dark. Due to a complete lack of any matter, sound waves cannot be transmitted; there is no orientation by gravity; the radiations are hazardous to life and dangerous rocks and meteors hurtle by. Not only these, a long flight through space presents the problem of supplying oxygen, food and water, and of getting rid of body wastes. Man's daily needs are about 2,200 grammes of water, 400-500 grammes of food and about 1000 grammes of oxygen.

THE EFFECT OF ACCELERATION: In order that a spaceship may leave the gravitational forces of the earth and orbit around it in the space, it must obtain a speed of 40,000 kilometres per hour. This means that the vehicle must be brought from a stationary position to a speed of 40,000 kilometres per hour in a few seconds. This sudden acceleration (rate of change of speed) exerts an enormous pull on the occupant of the spaceship. You can understand the effect of acceleration by a simple example—when your car starts to move, your body is pressed against the back of your seat. This accelerating force, which has the effect of increasing your weight, is measured in units called g. Normally our bodies are being subjected to the force of one g. In an ordinary elevator, we may be subjected to forces up to two g. A person moving up in a high speed elevator may, however, be subjected to a pull of five to seven g. Under high g. blood rushes towards the lower side of the body, and the heart can no longer keep it circulating through the

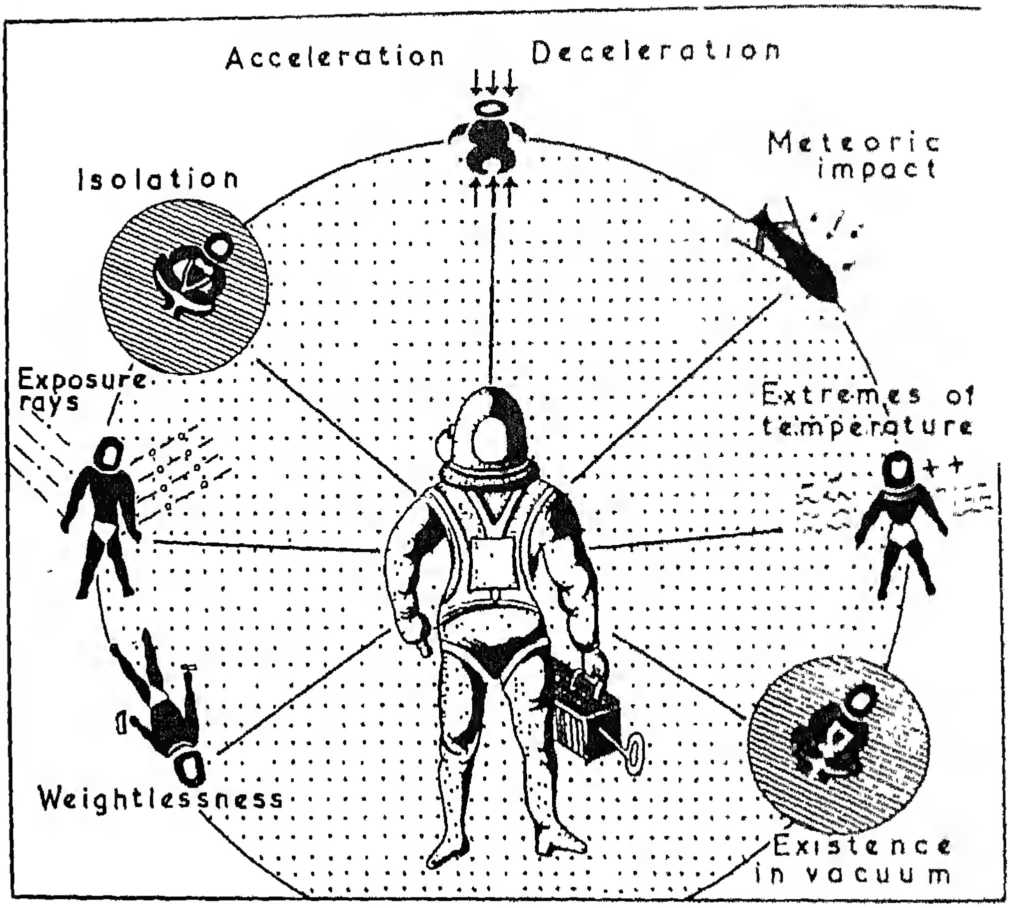

Fig. 4 Conditions experienced by a spaceman

arteries and veins. This results in a failure of the brain and retina of a person who is in a standing position.

In a space flight the first exposure to rapid acceleration is during the boost phase. A second build-up of g forces comes during the re-entry of the space craft. One may encounter forces up to 11 g or even more which is well above the tolerance of ordinary men. However, with prior training, such as by whirling in specially designed centrifuges, it is possible to stand a high gravitational pull without any ill effects.

Experiments also indicate that as compared to a standing or sitting posture, the adverse effects of rapid acceleration and deceleration are much less pronounced if a person simply lies down. In fact, in the space capsule the cosmonaut's seat is so fixed that during take off he lies horizontally on his back.

THE EFFECT OF WEIGHTLESSNESS: The period of the spaceship's rapid acceleration lasts only a few minutes. Once the desired velocity and height have been reached, the power is shut off. At this moment, the g-factor ceases, whereupon the cos-

monaut begins to experience the sensation of weightlessness. Because the earth is so far away, its gravitational pull now exerts practically no effect on his body. If he moves his legs or hands, he hardly feels it. The sense of balance is also lost.

Body Pressure in Space: The reduction in barometric pressure itself can be the cause of a morbid condition. When pressure around the organism is lowered, the gas in different cavities of the body and in the blood expands damaging the tissues and clogging the vessels. There is also the danger of the boiling of blood. This problem has been successfully solved by developing hermetically sealed cabins in which the desired level of barometric pressure can be maintained. Should a leak develop in a spaceship cabin during flight, the cosmonaut is additionally protected by a specially made space suit. Basically the suit is a tailored rubber bag, a man-shaped balloon, and it is the cosmonaut's final protection against disaster. The pressure-suit is connected to a pump through a pressurestat which can accurately hold a uniform pressure.

Respiration: At 26 kilometres above the earth, the density of the air is only about 4 per cent of that at sea level. Beyond an altitude of 112 kilometres, there is practically no atmosphere and therefore no oxygen. However, after training, man can exist in an atmosphere of approximately one-half the normal oxygen content on earth without discomfort and still be reasonably efficient.

Extremes of Temperature: Our atmosphere absorbs much of the heat radiating from the sun thus affording us a chance to live. However, in space this insulating blanket is absent and therefore there is nothing to ward off the high temperatures produced by sun's radiations. Also, there is no atmosphere in space to conduct the heat away from the space ship. Thus a ship in outer space would absorb the high intensity of sun's rays on the side of the ship facing the sun, whereas the side away from the sun would be extremely cold. However, the greatest danger is due to heat generated during the re-entry of the ship into the earth's atmosphere. At the great speed of movement of the space ship, high temperatures would be built up around the ship as soon as it begins to collide with the gas molecules of the atmosphere. The heat generated by this friction has to be reduced in order to prevent the ship and its occupant from burning up. This is done by slowing down the ship in stages as it returns to the earth's atmosphere and also by covering the ship with heat resistant material.

Radiation Hazards in Space: In addition to the visible light and infra-red rays, the outer space abounds in ultra-violet and cosmic rays. The ultra-violet rays are derived from the sun and cause severe burns as well as blinding. The cosmic rays are produced either from the exploding stars or from the sun itself. They have high energy and great penetrating power and cause genetic mutations. The atmosphere of the earth filters out the ultra-violet rays to some extent and the cosmic rays alsmost completely. In space, however, there is no protective atmosphere and thus the cosmonaut has to be protected from their effect.

Experiments indicate that for short periods of flight we need not fear such damage in space. Monkeys have spent as long as 35 hours in balloons at an alti-

tude of 27 kilometres, with no observable genetic change. Balloons have also carried black mice to altitudes of about 30 kilometres and exposed them to cosmic rays When these mice were returned to the earth, their coats had turned white but no detrimental genetic effects were observed. Moreover, the wall of the cabin affords a good protection against these radiations. However, for journeys to moon and other planets, which may take several months, cosmic radiation does pose a serious problem

Psychological Effects of Space Travels

We are all used to alternating periods of day and night. Tests indicate that a person cannot tolerate either day or night indefinitely Spaceships, therefore, will have to be equipped with apparatus capable of producing artificial day and night cycles in order to accommodate this psychological need in long trips. The sensation of weightlessness and the long periods of time spent in cramped quarters are other psychological problems of space travel. However, most of these problems can be solved by an adequate training programme which the spacemen undergo before flight.

Strangely enough, the most difficult problem to overcome has nothing to do with the mechanics of the space craft. Man's greatest enemy in space may be boredom According to current estimates a round trip to the nearest planet Mars will require 520 days. Passengers on such trips will have to be provided with some means of activity which will relieve the monotony of uneventful days and nights in a small, closed capusle. Even the success of the trip may depend on this problem. Boredom often leads to carelessness, and there is little or no allowance for mistakes in space voyages.

What Makes a Good Spaceman

On knowing about the exciting experiences of the cosmonauts, you too might be secretly tempted to avail of a chance to travel in the space. You might also be wondering whether you will be able to brave the rigours of the journey.

Anyone who wants to become a spaceman should have tremendous physical and moral strength He must be able to adapt his psychology to the complex conditions of the cosmos. This is achieved by appropriate training. Many tests have to be given to the candidates to determine their physical fitness and psychological stability. One of the initial tests is to place a man in a chamber completely devoid of light and sound and leave him there alone for 48 hours. The purpose of this test is to determine how well he can tolerate such absolute quietness and isolation. Following this are tests to determine how a candidate will react to the severe acceleration to which his body will be subjected during the initial period after a rocket is blast off. This is done by placing the man in a special centrifuge and whirling him round at high speeds. Another test is to place the candidate in a room in which the temperature is raised to 54°C, whereupon he performs specific tests to determine how well he can maintain his reactions at such high temperatures. The candidate is also subjected to ear splitting noises. Also, by means of a series of vacuum pumps, the atmosphere is removed from the room so that he is placed at an 'altitude' anywhere up to 32 kilometres. These are but only a few of the tests that

candidates must undergo to determine their fitness and to train them for what they will encounter during long periods of space flight.

The Future

With the achievement of success in space flight a glorious chapter has been opened in the history of human adventure. Many fundamental problems have been understood and solved, but more complicated problems lie ahead. After the cosmic group flights by the Russians, it has become clear that prolonged manned flights in space are possible. Ahead lie explorations of Moon, Mars, Venus and flights to the furthermost parts of the solar system and beyond it.

Experts maintain that manned flights, with the cosmonauts in a pressurised cabin in which air regeneration is ensured by special chemical substances and the crew's nourishment by supplies taken from the Earth, can last only for 15-20 days.

Interplanetary flights lasting several months or even years, will require different methods of regeneration of the artificial atmosphere and of replenishing food, water and other supplies. In a spaceship this can perhaps be done by creating a midget model of the Earth in it with a closed ecological cycle somewhat like an aquarium. For this reason manned spaceships will have to carry plants and animals which will help to maintain the necessary chemical composition of the atmosphere. The vegetable kingdom on board the spaceship will also become the main source of organic substances which will serve as food for the cosmonaut and the animals. The unicellular green alga *Chlorella* is a kind of oxygen factory intensively consuming carbon dioxide and giving off oxygen. One litre of *Chlorella* can produce 10 litres of oxygen in 24 hours. *Chlorella* is unpretentious and multiplies very rapidly. So it would be of great advantage to carry *Chlorella* in spaceships to provide food and for exchange of gases. Of great importance in a closed circulation are micro-organisms, through which the excretion of men and animals can be drawn into this process of biological balance and used effectively. Thus the closed ecological system of stellar ship represents a 'factory-laboratory' where carbon dioxide and other waste products of metabolism will produce everything necessary for the cosmonaut's vital activity. Most likely within a few years, some of these theoretical possibilities will be translated into realities and a few of you may be reserving your tickets for a holiday journey to the moon.

Revolution in Secondary School Mathematics

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SECONDARY School Mathematics (S.S.M.) is the basic structure on which the whole superstructure of mathematics, physical sciences, social sciences and technology in the universities and technical institutions rests. Weaknesses in the basic substructure have led in the past and can lead in the future to considerable weaknesses in the superstructure.

There has been a tremendous upsurge of research activity in mathematics during the last few decades. *Mathematical Reviews* which gives brief reviews of research papers and books had 1650 large double-column pages in 1960, it had about 2200 pages in 1961, about 2500 pages in 1962 and is likely to have 3000 pages in 1963. Mathematical knowledge has been estimated to double in a period of about fifteen years. More mathematics knowledge has been gathered since 1947 than there was till that year. Our secondary school syllabi in mathematics have changed very little, either in spirit or in content, during the last hundred years or so. It is not uncommon to find textbooks written forty or fifty years ago still being used in many schools. We have been completely static too long in a dynamic world.

The tremendous explosion of mathematical knowledge has had its impact on university syllabi in most countries of the world. Subjects like abstract algebra, topology, measure theory, functional analysis, etc., began to find a place in American universities' syllabi about thirty years ago and in Indian universities' syllabi about ten years ago. Even now quite a large number of Indian universities do not have these subjects in their M.Sc. syllabi, but every year we find four or five universities introducing these subjects. Some have introduced some of these even in their B.Sc. syllabi. This has introduced certain 'squeezing' in the university syllabi. The overburdening of university syllabi may result in the students emerging with hazy notions about the new concepts. It is felt therefore that some of the new load must be taken up by the secondary school courses.

There was a time lag of about fifteen years in western countries between the introduction of new concepts in universities and schools. A similar time lag is likely to occur in our country. Our schools should be ready to change drastically during the next five or six years. Preparations must start on a large scale right from now to make this transition smooth.

A secondary school student of physics comes to know about a large number of discoveries and inventions of the twentieth century. A mathematics student seldom

knows any thing discovered after the seventeenth century. Naturally a student does not feel as much impelled to do creative work in mathematics as he does in physics. If we have to attract the right type of talent for mathematics we have to introduce at least some modern concepts at the school level

Some of the topics introduced in secondary school syllabi in the U S A., are set theory, logic probability, statistical inference, algebraic structures, matrices, axiomatic method, linear programming, etc. Some of these do not find a place even now in the syllabi of some of our universities though they are being introduced gradually. It is obvious that teachers of S.S. mathematics will not be able to teach these topics without adequate preparation. These topics are not more difficult and do not necessarily require a higher degree of maturity than the topics included in our present S.S syllabi. They are however different and reflect more correctly the spirit and needs of modern mathematics.

During the last thirty years new applications of mathematics to social, agricultural and behaviouristic sciences have been discovered. An almost new mathematics-based science of statistics has developed with very wide applications to physics and chemistry, engineering and technology, agriculture and animal husbandary, business and commerce, public health and demography, etc. These new applications have to be reflected in our S.S. mathematics syllabi. In fact the progress of some of the social sciences like economics has been considerably retarded in our country, as students and teachers of these subjects were not provided with an adequate background of mathematics in their S S. courses

During the last two decades entirely new applications of mathematics to industry and management sciences of vast potentiality have been discovered in the form of the science of operations research. Techniques of inventory control, mathematical programming, queuing sequencing, routing, replacement, maintenance, reliability, competition, search, information, cybernetics, etc. have brought about vast changes in the outlook of a large and influential group of persons regarding mathematics. The mathematics required for these applications is very often different from (though not more difficult than) that required for applications to physics and engineering.

Since a large number of secondary school boys who may not read any more mathematics have to enter industry, their needs must also be met by S.S. mathematics.

It is not only the number and quality of new applications of mathematics that has been increasing in recent years, the rate at which this number increases has also been increasing. This implies that S S.M. should not only be such as to allow the students to appreciate and understand current applications, but should be so designed as to enable them to appreciate those applications that may be found in the near future. This obviously necessitates that we teach general principles consistent with the spirit of modern pure and applied mathematics rather than be lost in particular details.

Modern developments in science and technology require a new habit of original and critical thinking and the foundations

of such a habit have to be laid in S.S M. We have to develop courses which emphasize basic concepts and not only give the students certain algorithms for carrying out operations, but give them the 'why' of these algorithms. Our secondary school syllabi should reflect the spirit of advancing frontiers of both pure and applied mathematics.

The developments associated with space age and electronic computers have influenced the type of mathematics required and this should again be reflected in our secondary school programmes.

The teaching of S.S. mathematics should bring out its chief characteristics such as abstractness, precision, generality, logical nature, etc., and any topic which does not satisfy these standards has to go. Theorems in mathematics are as true today as they were yesterday but they can become obsolete as much more general or more interesting or more abstract or more useful theorems may be discovered.

Our history shows that we as a race have always had a special aptitude for mathematics and our researches always had a stamp of quality.

Aims of Teaching Secondary School Mathematics

Mathematics is taught in secondary schools for one or more of the following reasons

i. It is useful in daily life, business, commerce, banking, auditing, navigation, surveying, etc.

ii. It provides special training in concentrated, logical, precise, abstract, general, quantitative, economic symbolic and rigorous thinking.

iii. It provides one of the most beautiful structures of thought that mankind has evolved over the ages which should be studied independently of its uses. This refers to the aspect of mathematics as an 'art' or as one of the 'humanities'.

iv. It is an indispensible tool for the study of physics and all branches of engineering and technology.

v. It is a very useful tool for the study of social sciences like economics, sociology, psychology, etc.

vi. It is fundamental for the study of mathematical statistics which has such wide applications in almost all fields of human activity.

vii. It is basic for the development of the new science of Operations Research which is finding so many applications in industry and defence.

viii. It is basic for the use of modern electronic computers.

Among those topics which meet some or all of the above criteria, we will have to choose those which are more useful to the group of students under consideration. For some students secondary school course is a terminal course, for others it is a gateway for entry into a university. Some will cease to study mathematics after secondary school even if they continue university education, others may continue to use it as a tool and still others may take to mathematics as a career. It may be necessary to have different mathematics courses for the different groups or we may have basic mathematics courses common to all groups and then supplement it by optional courses which may be different for different groups.

The Present Syllabi

The present secondary school syllabi and methods of teaching in our schools give not only very defective mathematics, but give wrong notions about the nature of rigour, proofs, etc. The syllabi and methods should be such as to project at least a reasonably correct picture of mathematics in the minds of the students

Mathematics has too long been taught by rule-of-thumb methods. It has almost been taught as mechanics is taught to an uneducated person in a motor workshop. Certain rules are given to the students very often without proofs or with 'proofs by intimidation' or with 'proofs by waving of hands' or with proofs resting on the authority of the teacher. The students are expected to apply these rules to numerous examples and they have to go on applying these rules till they are completely 'brainwashed' and forget their initial objections to the rules. Religious teachers or communist preachers may use these methods, but these methods should certainly not be used by mathematicians. The brainwashing is so complete that when students are told later that there exist fairly decent and useful mathematical systems for which (i) $ab \neq ba$ or (ii) $(ab)c \neq a(bc)$ or (iii) $ab=0$ does not imply $a=0$ or $b=0$ (iv) the sum of angles of a triangle need not be equal to two right angles, etc., they are not prepared to believe these statements.

The teaching at secondary school is so defective that very often a student has to unlearn at the college stage or at the research stage whatever he has learnt at the school stage, since he has not really or correctly learnt it. This unlearning is a painful and difficult process.

Mathematics is a subject in which a research worker has to start young and so the state of the secondary school course is particularly important for a primarily intellectual subject like mathematics. It is a fact, however, that some of us who have taught the traditional mathematics programme feel it is a miracle that some of our students became mathematicians considering the way we taught them. Perhaps they became mathematicians in spite of the present secondary school system.

A Brief Critical Examination of the Different Branches of Mathematics

The present high school, higher secondary and intermediate syllabi may be examined in the light of the above criteria.

ARITHMETIC: Very often a student repeats in the high school whatever he has done in class VIII, only he does more difficult and more complicated questions. This shows a certain wastage of time. Difficult questions can only be justified either if they are realistic or if they sharpen the intellect. A critical examination of the problems in an arithmetic book will show that an overwhelming majority of them are artificially created problems which are hardly likely to arise in practice. As for sharpening the intellect, we have much better and much more interesting topics in mathematics. In fact most of the problems refer to life fifty or hundred years ago. For example some of the concepts given in stocks and shares chapter do not occur anywhere in the real world except in Indian arithmetic textbooks. They seldom refer to real arithmetical problems which arise in our national life, e.g., in planning, in construction of dams, bridges and steel

plants. A real effort has to be made to collect such problems and include these in our text. This will make arithmetic more interesting and also widen the general knowledge of our students. However, most of the arithmetic needed for this purpose can be finished by class VIII.

Some particular comments may be made at this stage.

i. Instead of writing numbers in trillions or in Roman numericals (which no body uses now except for numbers up to a hundred) it will be far more profitable and interesting for a student to do a few calculations in the binary, octad or duodecimal systems. The place value system and the importance of zero have to be clearly understood.

ii. 'Practice' had never any use and at least with the introduction of decimal coinage, weights and measures, it has become completely useless.

iii. 'Averages' must be taught in the context of descriptive statistics only.

iv. Instead of doing complicated and artificial problems on L.C.M. and G.C.M., it would be worthwhile to teach the students Euclidean algorithm to justify the processes involved which at present are assumed to give the result.

v. All complicated questions on 'simplification' of expressions 'involving vulgar' fraction should go. Such expressions never arise in practice.

By [illegible] up to class VIII and [illegible] complicated problems, the time required for arithmetic can easily be cut down to one-fourth of the time devoted to it at present.

ALGEBRA.—The teaching of algebra can be considerably simplified by eliminating artificially created and complicated problems. For example we have a large number of specially framed examples in factorization giving false impression to the student that every expression can be factorized. He is surprised if he finds some expressions which cannot be factorized in the domain of integers. However the number of the expressions which can be so factorised is a negligible fraction of the total number of possible expressions so that one should be surprised when one comes across a factorizable expression. The same remarks apply to H.C.F. and L.C.M., etc. In fact time spent on high school algebra can be easily reduced by at least fifty per cent. In intermediate algebra, quadratic equations have to be retained, though the only topics which are of interest are the solution of quadratic equation, the nature of roots and the sign of a quadratic expression for real values of *x*. In fact some general theory of quadratic forms can be done in the same time. Formulae for the sum of A.P., G.P., etc. should be retained, but the *n* arithmetic means, *n* geometric means, harmonic means have to go. They have absolutely no use whatsoever and we spend so much time in solving complicated problems on the same. Permutation and combination problems are becoming more and more important, but here too examples should be drawn from more recent applications like sequencing theory.

Binomial theorem is of course useful and has to be studied. Thus in intermediate algebra, the time saved would be of the order of twenty-five per cent only.

GEOMETRY : Here perhaps a most drastic revolution is called for. One might even support Prof. Dieudonnes slogan 'Euclid must go'. Euclids geometry is a beautiful but logically imperfect example of axio-methods. We have better and more logically perfect axiomatic systems in arithmetic, algebra and geometry and these must be taught. We spend a good deal of time on theorems and construction of triangles under various conditions Triangles are beautiful figures but there are more beautiful figures in mathematics. The time spent on triangles and quadrilaterals is out of all proportion to their importance. Most of the theorems on circles can be more usefully proved by co-ordinate geometry The useful part of Euclidean geometry can be easily done in at most twenty-five per cent of the time that is devoted to it at present.

TRIGONOMETRY : Here again we can have a useful slogan 'Trigonometry as a separate discipline must go'. Part of it can be usefully absorbed in algebra courses and part of it in calculus courses. Trigonometry was introduced in the west three hundred years ago when almost every college graduate became a sea captain or a surveyor. A sea captain needed it for navigation, a surveyor needed it for surveying new continents. We have more powerful methods based on radar and electronic devices for navigation, and surveying is out of fashion even in technical institutes. We again spend so much time with the triangle here. We do complicated problems in solution and circumscribed circles, trigonometric identities when the sum of angles is two right angles and so on. It is all unnecessary. In all this we forget the important role of periodicity of trigonometrical functions of multiples and submultiples of angles. Hyperbolic functions can be studied as part of calculus. Again wherever it is done, the total time devoted to it should not exceed twenty-five per cent of the time devoted to it now.

CO-ORDINATE GEOMETRY : This is a useful branch and the properties of conics which were useful in astronomy are now useful in discussing satellite orbits. Even here complicated problems can be usefully chopped and a unified course of co-ordinate geometry and calculus can be and has been developed.

CALCULUS : This is again a useful course and in fact part of the time saved from other courses can be used in strengthening this course. At least in an intermediate course or a 12-year secondary course, a first course in calculus must be completed at this stage. Even here considerable savings can be effected by reducing drilling in differentiations which is involved in study of certain topics such as evaluation of indeterminate forms, curvature, etc., which as taught today are nothing but examples of differentiation. Similar examples can be seen to occur in integral calculus. In addition we should not only draw illustrations from differential geometry, but also from so many other fields where calculus is applied.

MECHANICS : This is intended to serve as an important example of applied mathematics; but what do we do here ? We repeat the principles taught to the student in his physics course and do only more complicated problems most of

which are again completely artificial. We repeat the same course again in B.Sc. and do still more artificial and still more complicated problems. It is open to question whether our students get some real respect for the power of mathematics by studying this course. We can teach a more realistic and more respectable course on applied mathematics by drawing illustrations from linear programming, economic models, biological sciences, probability and statistics and those topics in mechanics not usually taught in physics. Some topics like centre of gravity, centre of pressure and moments of inertia can be included in integral calculus course, others like simple harmonic motion, projectiles, central orbits can be included as illustrations of solutions of ordinary differential equations. Mechanics as a separate course can go.

General Remarks

It will be obvious from the above discussion that as much as fifty per cent of time can be saved by a judicious selection from the present courses and this time can be usefully utilized for introducing new topics discussed in the next section.

It will be useful exercise for a professional teacher of school or college mathematics to find for himself how much of each of the subjects above satisfy each of the criteria. The same exercise can be repeated for the courses discussed in the next section.

A still more useful exercise will be to make suitable combination from courses given above and those given in next section to satisfy each of the criteria separately and also in various combinations.

To introduce new topics in a syllabus does not require as much courage as is required for [illegible] is a very [illegible] certain topics over a certain period of time, we become convinced that whatever we do is the right thing. We [illegible] examine the above programmes in [illegible] fashion almost as if we are strangers from another world [illegible] with the developments in pure and applied mathematics who evaluate [illegible] syllabi at their own merit.

NEW TOPICS THAT CAN FIND A PLACE IN THE SCHOOL CURRICULUM

Advancing frontiers of mathematical research and increasing rate of applications of mathematics make it imperative that some at least of the following topics find a place in the school curriculum. In fact most of these have been introduced in new experimental programmes in the U.S.A. and on the whole their introduction has been enthusiastically received by students and teachers alike.

Set Theory: This should have a four-fold purpose:

i. introduce students to such symbols as $\in$ (belonging to), $\cup$ (union), $\cap$ (intersection), $\subset$ (inclusion), $\Rightarrow$ (implies), $\sim$ (negation), $\exists$ (there exists), $\Leftrightarrow$ (if and only if), ϕ (null set), $\wedge$ (conjunction or and), $\vee$ (disjunction or or) etc. The symbols will give new look to school mathematics. Moreover these symbols represent concepts that bring clarity and conciseness to thinking and make compact the mathematical ideas in a nice way.

ii. introduce students to the concepts of logic.

iii introduce to a system in which they come across new laws like $a+a=a$, $a \cdot a=a$, $(a+b)(a+c)=a+bc$, $a+ab=a$ etc. The experience is bound to have a liberating influence on their minds and bring to their notice the importance of commutative and distributive laws and existence of identity elements.

iv introduce the student to Boolean algebra and switching algebra if time permits. Boolean algebra can provide a nice example of an axiomatic system and switching algebra can provide an elementary example of applied mathematics.

Number Systems And Algebraic Structures

The study of various number systems, noting for each system, the properties which constitute the properties of a group, ring, integral domain and field is bound to be an enriching experience. The equivalence and order relations can be introduced at this stage and various algebraic structures can be defined. By giving a large number of examples of each structures, the power of the abstract method can be focussed on the mind of the student.

Matrices And Linear Algebra

Determinants and matrices up to order 3×3 can be introduced in a unified fashion. Matrices have so many applications in so many fields that it is desirable that these are introduced to the students at the S.S stage. The solution of a system of linear equations which is done even now will become more meaningful with the introduction of matrices. Some persons even suggest the introduction of vector spaces contending that the study of two dimensional vector spaces can replace a good deal of Euclidean geometry. The theory of vectors, linear algebra and parts of geometry (synthetic or analytic) are essentially three different ways of expressing the same mathematical fact. The theory of complex numbers provides a fourth interpretation for plane geometry. All these points of view should be presented to the student in a unified fashion.

Probability and Statistical Inference

In some secondary school courses study of descriptive statistics such as frequency distribution, histogram, mean, median and standard deviation has been introduced, but this is not enough, since the object of this course should be to teach inductive inference about the nature of the population from that of the sample. For this, the course can consist of classical probability theorems, binomial and Poisson distributions, principles of testing of hypotheses, sequential and non-parametric tests. This should be a compulsory course for those going to universities for social and biological sciences and not intending to take further mathematics courses there.

An Alternative Course on Applied Mathematics

Most of the applications of mathematics to physics require the use of differential equations and cannot be given at this stage, but a number of recent applications belong to the combinatorial and discrete domains and require only elementary calculus and can be given at this stage. These refer to the fields of economics, biology, operations research and decision making processes. The course can include linear programming with two

variables, simple inventory models, simple economic models and even simple queuing problems. In fact there is a rich variety of applications and the course should be so designed that the pre-requisite mathematics does not exceed the student's knowledge of the subject.

Calculus

Calculus is already taught in intermediate courses, but its scope has to be considerably widened, as indicated earlier.

GENERAL REMARKS—EVOLUTION OR REVOLUTION

It is felt that by saving time on classical portions all the above topics can be taught in a twelve-year school programme, i.e. in a four-year secondary school programme. Where there is only a three-year S.S. course, a choice out of the new subjects has to be made. This has obviously to depend on local conditions and on the future interest of the students to whom this course has to be taught.

It is agreed that the present school teachers cannot teach this course, for almost none of them studied these courses in their college days. A huge programme of in-service training of teachers costing about ten to twenty crore of rupees has to be undertaken if this programme is to be implemented. This programme is outlined in a later section.

There can be two methods of bringing about this change. In the evolutionary process, we go on giving up gradually some topics in the older syllabi and go on introducing some new topics and at the same time go on changing our emphasis. In the revolutionary process, the present syllabus is wholly replaced by a new integrated syllabus. The second method has been [illegible] U.S.A. [illegible] rely new textbooks [illegible] mentation [illegible] work between the [illegible] topics, on the other hand [illegible] approach is presented.

DRIVE TO IMPROVE SCHOOL MATHEMATICS IN THE U.S.A.

In the last ten years or so an intensive drive has been made in the U.S.A. for improving secondary school mathematics. The drive has so far cost at least a hundred crore of rupees and has mobilised the efforts of hundreds of university professors and of forty to fifty thousand school teachers and administrators. The drive may have important lessons for us.

The seriousness with which the U.S.A. has taken up this responsibility can be judged from the fact that the National Science Foundation (NSF) has contributed more than 4 million dollars (equivalent to about two crores of rupees) to the School Mathematics Study Group (S.M.S.G.) for the development of sample textbooks. Besides a number of other foundations and universities have also spent considerable sums on the development of alternative textbooks. A still larger amount (about 50 crores of rupees by NSF alone) has been spent on a large number of Summer Institutes for secondary school teachers of mathematics. A large number of top university professors have spent considerable time and energy in giving lectures in the Summer Institutes and in the writing of the sample textbooks. The comparative effort in our country, even considering the backward economy of our country has been completely negligible.

Summer Institutes of Mathematics

More than thirty thousand teachers of S.S. Mathematics have been trained in the new programmes at Summer Institutes of periods ranging from four to eight weeks. The teachers have been amply compensated for their loss of vacations.

Preparation of Model Textbooks

The most extensive effort in this direction has been made by the School Mathematics Study Group (SMSG) with the financial support of the National Science Foundation (NSF). A joint team of about a hundred university mathematicians and a hundred school teachers wrote these books for classes 7 to 12. Each book is accompanied by commentary for the teacher giving him a comprehensive background for the textbook. These books have been tried with more than 100,000 students. The reactions of students and teachers have been examined in detail and the books are revised in the light of these reactions. The books have been written and re-written a number of times and now they are given to commercial publishers for being printed in their final form. Sample textbooks have also been prepared by University of Illinois Curriculum Study in Mathematics (UICSM), University of Maryland Mathematics Project (UMMaP), Boston College Mathematics Institute, Ball State Teachars College Experimental Programme, University of Southern Illinois and others.

Teaching Aids

A number of states run regular weekly or biweekly television programmes on such courses as 'Contemporary Mathematics', 'Language of Mathematics', etc. Programmes have been given both for teachers and students New York State has made kinescope recordings of a full year televised course of 89 half-hour lectures in Modern Mathematics and it telecasts them from different centres. The 16 mm films are shown to various groups of teachers who discuss these. The Minnesota National Laboratory has prepared 210 half-hour films 'Films for Mathematics Teachers'. These give a series of demonstration lessons using the S.M.S.G materials for each of the grades 7–12.

CONTRIBUTIONS OF PROFESSIONAL ORGANIZATIONS AND GOVERNMENT AGENCIES

The National Council of Teachers of Mathematics (NCTM) works for the general professional improvement of teachers through conferences and through its journals, *The Mathematics Teacher* and *The Arithmetic Teacher*. It also publishes yearbooks and supplementary publications for specified needs. Its sub-committees have studied problems like professional standards, relations with industry, mathematics for the slow learner, mathematics for academically gifted pupils, films for mathematics, nature of mathematical thought for secondary school students, place for mathematics in a changing society, etc.

The Mathematical Association of America (MAA) contributes through the section on Mathematical Education Notes in the American Mathematical Monthly and through the advice of its Committee on Undergraduate Programme in Mathematics (CUPM) for pre-service training of mathematics teachers.

The National Science Foundation (NSF) makes financial grants to the scientific community, primarily to colleges and universities, in support of programmes designed to improve mathematics education. Among these are summer, academic year and in-service institutes, SMSG films, etc.

The National Aeronautics and Space Administration (*NASA*) supplies to mathematics teachers publications suggesting up-to-date and exciting applications of mathematics that they are teaching

The Conference Board of Mathematical Sciences (CBMS). Forum for Mathematical Education serves as a channel of communication on problems and suggestions for their solutions.

College Entrance Examination Board Commission on Mathematics regularly suggests revisions of secondary school syllabi for college-bound students.

U S Office of Education (USOE) contributes to in-service education through grants and the services of its officers.

EFFORTS TO IMPROVE SECONDARY SCHOOL MATHEMATICS IN EUROPE AND INDIA

In May 1961, the organization for European Economic Co-operation (OEEC) published the report of the Royaumont Seminar on 'New Thinking in School Mathematics'. This seminar was jointly sponsored by OEEC and Mathematical Association of America with a grant from the NSF. The report gives a brief survey of mathematical education in West European countries and suggestions for reform.

In India several symposia on teaching of mathematics have been organized from time to time in the conferences of the Indian Mathematical Society and the Indian Science Congress, but they were purely academic discussions and related mostly to college and university mathematics. In [illegible], a symposium specifically on teaching of mathematics in schools was held under the auspices of the Calcutta Mathematical Society.

In February 1956, a South Asian Conference on Mathematical Education was held at the Tata Institute of Fundamental Research, Bombay. The report of its sub-committee for school mathematics recommended introduction of solid geometry, elementary calculus and statistics in secondary schools.

In May 1960 and 1961, the Mathematics Seminar of Delhi University in co-operation with the Directorate of Education, Delhi, organized three-day [illegible] of secondary school teachers of Delhi where some of the ideas contained in this report were presented and discussed.

The first practical step was taken in the organization of the First Summer Institute of Mathematics at Ramjas College, Delhi in May 1963. This was jointly sponsored by the National Council of Educational Research and Training and the University Grants Commission in collaboration with the Teachers College, Columbia University and U S-AID. It was the first experiment of its kind in which teachers from schools, colleges and universities made a concerted and combined effort to reorient the curriculum and teaching methods. Thirty-four secondary school teachers from all over India participated. Lectures were delivered on Set Theory, Algebraic Structures, Probability, Statistics, Boolean Algebra, Nature of Mathematics, Applications of Mathematics, etc. Besides, there

were group discussions on SMSG books and review of other 'enriching materials' books. The Institute, in which the author had the privilege of active participation, created among the participating teachers a great deal of enthusiasm for modern mathematics. It is expected that a number of such Institutes will be held this summer.

Another important step has been taken in that a group of experts under the leadership of Prof. Ram Behari is engaged in writing improved textbooks which are likely to form the basic texts for the forthcoming Summer Institutes. Later these books will be tried in a number of secondary schools all over the country and the results will be critically evaluted to improve the textbooks

SUGGESTIONS FOR IMPLEMENTING THE PROGRAMME

The magnitude of the programme mainly arises from the number of persons involved. Lakhs of secondary school students and thousands of secondary school teachers have to be involved. For the success of the programme, hundreds of college and university teachers and educational administrators have to give their wholehearted and enthusiastic co-operation. A gigantic in-service teachers training programme has to be undertaken to train at least one hundred thousand teachers in the next ten years or so. Each teacher will require training programme lasting at least two months for this. A large number of suitable textbooks and teacher's guides have to be written and re-written.

Since the co-operation of such a vast number of persons is necessary there should be a strong publicity movement for creating a general awareness of the necessity for all these changes. There is a great deal of complacency all round. There is a feeling that only teaching methods need be improved. In fact the teachers who gathered for the first Summer Institute at Delhi did not see the necessity of associating university teachers with the Institute. They felt that there should be only training college teachers to give them demonstration lessons for the teaching of the present syllabus in the present spirit. Their attitude however, changed in a few days as the picture of Modern Mathematics was unfolded before them. The feeling that there is a great deal of dead-weight in our syllabus and that the spirit of the S.S. Mathematics presented is quite far away from that of Modern Mathematics was simply not there. Improvement in syllabi is meant to imply that certain topics should be bodily lifted from B.Sc. and Intermediate syllabi and put in Intermediate and High School syllabi respectively. This 'change of origin' will solve no problem at all. There are subjects which do not even occur in the university syllabi or occur at much more mature level, but which are not more difficult than our present secondary school topics, which correctly reflect the spirit of modern mathematics and which have simply to be taught at the secondary school level because of their tremendous importance to social and physical sciences and to technology. The awareness of such topics is also limited to a small class of persons. The author of this report himself was not so forcefully aware of all these till a few years ago. His active association as organizing secretary of the six summer schools for college teachers and the two summer seminars for secondary school teachers held at Delhi and with the first

summer institute and his association with operational research activities in the country have made the various issues clearer to him. He feels very strongly that a wide publicity to these ideas is of the utmost necessity. This can be done both by professional organizations and government agencies.

The second great necessity is for suitable literature to be made available to the secondary school teachers. It will take us sometime to prepare our own material. In the meantime it would be worthwhile for the government to print SMSG books (with permission, of course) and make them available free to all schools and others who are likely to benefit by their use. Ten thousand sets of these books should not cost more than five lakhs of rupees and considering that 60 crores of rupees have gone in their preparation and that they represent the efforts of so many top mathematicians, the expenditure is worth incurring. In the meantime we should undertake the preparation of our own books and reference materials. A book suitable for our own needs on each of the courses can be prepared within a year.

The third great necessity is for suitable in-service training facilities for teachers. If we have to train one hundred thousand teachers during the next ten years, we shall have to train ten thousand per year. At least this is the rate at which they are training teachers in the U.S.A. This will imply a hundred summer institutes even if we agree to go to the limit of admitting a hundred teachers per institute. Each institute will require at least six well-qualified university teachers. Even if the government is prepared to spend funds, the requisite number of university teachers who can teach the subject in the right spirit is simply not there. This does not mean that we should not have summer institutes. We should have as many of these every year as our resources permit, but we should supplement these by other means as well. We should certainly consider the optimal utilizations of human resources. Availability of funds should not be a dominant consideration in such an important task.

Another important point to remember is that our teachers are low-paid and over-worked. We should not expect them to take up the responsibility of new courses without adequate financial and academic help. We can thrust the responsibility by introducing changes in syllabi and forcing them to teach new syllabi, but the teaching will become worse, to the great harm of the country. If they devote that time to their studies which they spend on tuitions or which they spend in well-earned rest, they should be adequately compensated. Even in the U.S.A. where teachers are better paid and carry less load of teaching, this compensation had to be provided in generous measure. We should pay the teachers at least an equivalent of the salary for the two months period they attend a summer institute. Then they need not be paid their T.A. and D.A. The railways should grant them railway concessions and they should not be forced to travel in first class when they may normally be travelling in third class. The boarding arragements should also be cheap for them.

Since we cannot hold many summer institutes, we may allow the teachers to

study at home through correspondence courses or independently and they may still be paid their two months salary if they can successfully pass in an examination meant to test whether they have grasped the new knowledge. In all large cities weekly lectures by university lecturers to help in this self-study effort should be arranged.

The total expenditure may be of the order of two or three crores of rupees per year, but this money has to be found if we want to seriously improve our Secondary School Mathematics and not just change it slightly here and there.

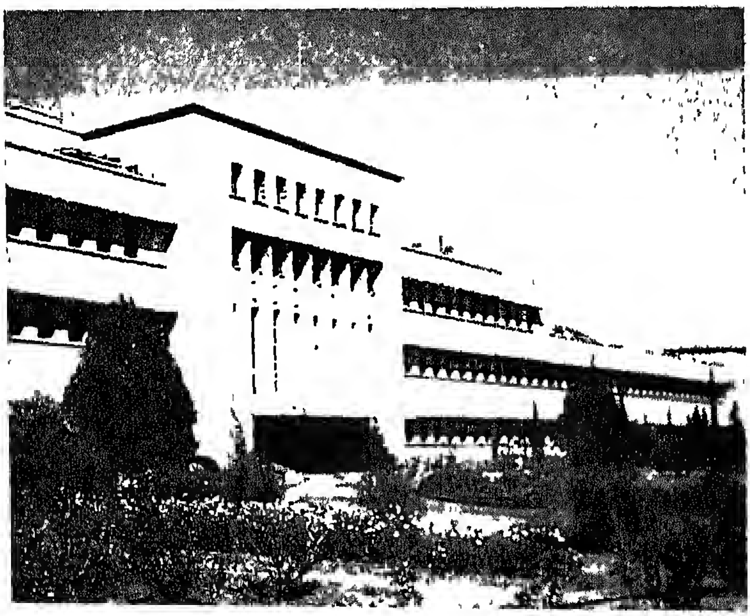
Professional mathematical societies and government agencies can co-operate in holding a number of seminars and symposia all over the country where the problems involved in bringing about a revolution in S.S. mathematics are freely and frankly discussed. Apart from the question of funds, there is bound to be a great deal of resistance to change. Even in the U.S.A. bitter controversies raged between the tradition-at-any-cost group and the revolution-at-any-cost group and the conferences helped a good deal in clarifying the issues and bringing about finally agreed solutions.

An urgent necessity at a professional level is to form some sort of an organization parallel to that of the National Council of Mathematics Teachers in the U.S.A which has done such useful work over the years. Such an association besides holding of conferences of teachers, can start a journal which can be a good medium for teachers.

National Chemical Laboratory, Poona

THE National Chemical Laboratory, Poona, situated about a mile west of the University of Poona, is on the way to Pashan village and the National Defence Academy. The campus has an area of 475 acres, including residential quarters for about 350 families

The foundation stone of the main building of the Laboratory was laid by the late Shri B.G. Kher, Chief Minister of Bombay on April 6, 1947. The building was declared open on January 3, 1950, by Shri Jawaharlal Nehru, Prime Minister of India. This was the first Laboratory to be opened in the chain of National Laboratories under the Council of Scientific and Industrial Research, which now number more than 30



The National Chemical Laboratory, Poona

The purpose of the National Chemical Laboratory inscribed in the entrance hall, is 'to advance knowledge and to apply chemical science for the good of the people.'

In fulfilment of this broad aim, much of the work of the Laboratory is directed towards the solution of technical problems of chemical industry in India, and the development of new industrial chemical processes using raw materials available in India.

The programme of the Laboratory is at present carried out in its ten divisions, namely, Physical Chemistry, Inorganic Chemistry, Organic Chemistry, Essential Oils, Biochemistry, Polymer Chemistry, Chemical Engineering, Organic Inter-

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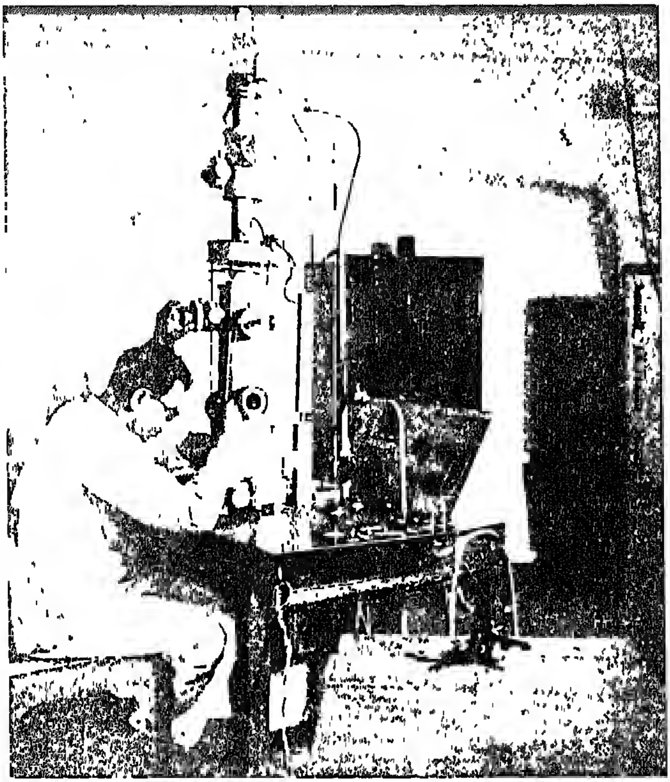
By the courtesy of the Director, National Chemical Laboratory, Poona.



Electron Diffraction Camera Finch type modified to hot cathode system.

Development and other Government Departments, by the specialised knowledge, experience and interest of the members of its leading staff. Research schemes of industrial interest, are also undertaken on behalf of private parties on easy terms.

Research Divisions

In Physical Chemistry, research is carried out on surface chemistry, solid state chemistry, crystal and molecular structure, properties of thin films and nuclear chemistry. The radiation laboratory, which is a part of the Physical Chemistry division, is separately housed in a new building. In this section, investigations are carried out on the effect of radiation on chemical and physical processes.

mediate and Dyes, Technical Services and Engineering Services. These divisions are well-staffed and provided with modern equipment and apparatus required for chemical research and process development. The scientific staff numbers more than 300 in a total strength of about 800 Many have high distinctions in different branches of chemistry and in chemical engineering, some are well-known for their achievements in research and technology.

In the choice of problems to be undertaken, the NCL is guided partly by the suggestions made by the Planning Commission, the Department of Technical

Chemistry of rare elements, chemistry of the solid state, preparation of special chemicals, flourine chemistry, and chlorination of titanium-bearing materials form the major subjects of research in Inorganic Chemistry

Organic chemical research is mostly concerned with research in natural products, synthetic organic chemicals, drugs, and natural and synthetic colouring matters. As an extension of its programme, the division of Essential Oils is specially oriented for work on essential oils, resins and synthetic perfumery materials, which includes systematic chemical examination of important essential oils,

of Indian origin and synthesis of valuable perfumery principles from available raw materials.

The programme of research in Biochemistry comprises work on biosynthesis and metabolism, microbiology and enzymes. The division has a national collection of industrial micro-organisms, which at present maintains the cultures of more than 1100 bacteria, yeasts, fungi and other non-pathogenic organisms. These cultures are available free of charge to scientific institutions for research work

In Polymer Chemistry, research is carried out on industrial polymers, physico-chemical studies of polymers, surface coatings, rubber and ion exchange resins. Both cation-exchange and anion-exchange resins are studied, including their preparation from Indian raw materials.

Selected laboratory investigations of industrial interest, when completed in any of the above divisions, are further developed in the form of pilot plant experiments in the Divisions of Chemical Engineering and Organic Intermediate & Dyes. These pilot plant investigations provide complete data for the design of plants of optimum size and performance. In addition, the Organic Intermediate & Dyes division pays special attention to modern methods of reactor development, chemical thermodynamics and applied kinetics, and undertakes pilot plant work on behalf of the dyestuff and allied organic chemical industries.

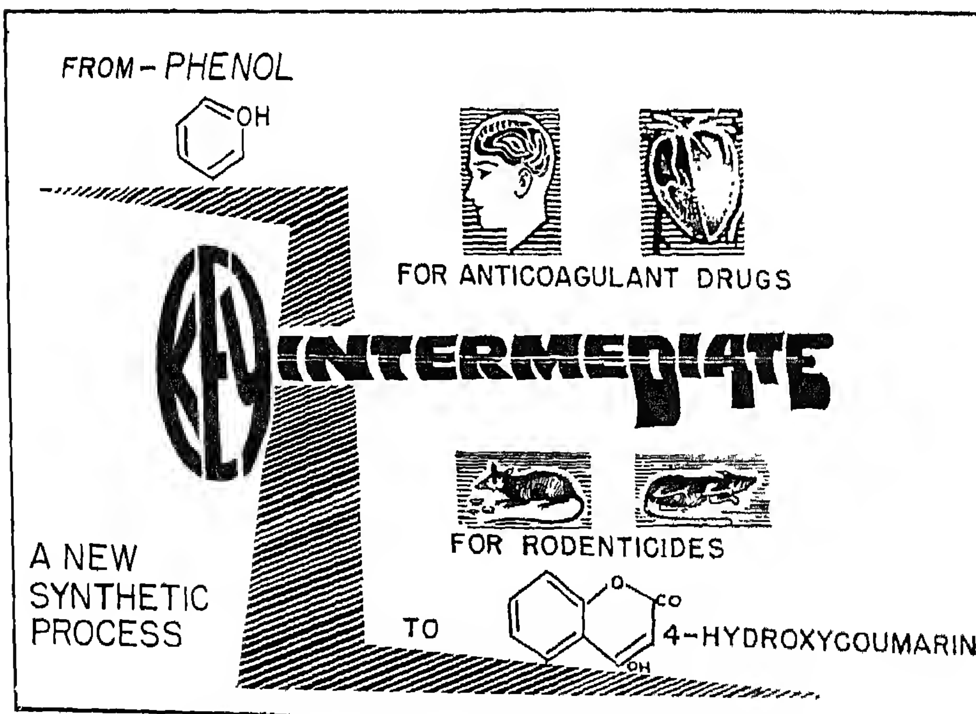


Fig. 1 A synthetic process of the preparation of 4-hydroxycoumarin from phenol in one step.

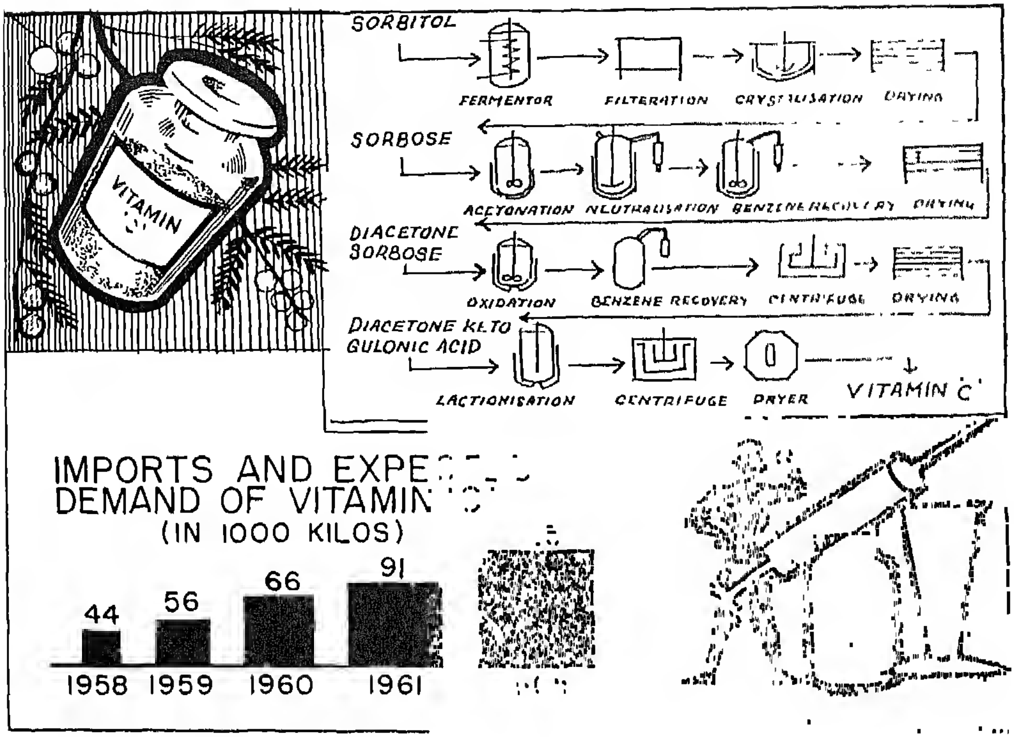


Fig. 2. Preparation of vitamin C from sorbitol

Services Divisions

Technical Services include photographic, photostatic and microfilming service (for scientific documentation), dealing with enquiries and assessment of commercial possibilities of products and processes developed in the NCL. Information as regards the availability and prices of raw materials, chemicals, apparatus, machinery, etc., is also maintained for ready reference by research workers.

The NCL has a well-equipped, workshop for Engineering Services, employing more than 150 skilled workers. It is responsible for the fabrication and maintenance of plants and equipment, and for essential services, e.g. power, refrigeration, gas, water, steam, etc.

A glass blowing section fabricates most of the special glass apparatus required for research, and has up-to-date facilities for grinding and table-work.

The Library, a key place in the organization, is equipped with over 10,000 books and receives regularly over 700 journals, both Indian and foreign.

Papers and Patents

The contribution made by the NCL to chemistry and chemical technology in India, during the last ten years of its existence, can be judged by over [illegible] research papers published in scientific journals of international status and from about 120 industrial processes patented in India. More than 20 amongst these are also patented in foreign countries.

Some Processes Released to Industry

Brief information on some of the projects, successfully completed in NCL and which have been taken over by the industry for commercial exploitation, will give a general idea of the work done in the NCL.

Rubber goods are generally manufactured by dipping process, from latex or from solid rubber by moulding. The moulding technique involves the use of milling, moulding and vulcanizing equipment. In the manufacture of certain rubber products, liquid rubber is preferred to solid rubber as it can be processed into any desired shape without costly machinery. A process for the manufacture of liquid rubber, has been standardized in the NCL, and it has been shown that the liquid rubber can be used for casting printers rollers and hard rubber linings.

In India, tobacco is cultivated on large scale in Andhra Pradesh, Maharashtra and Gujarat states. After cutting the leaves, the rest of the tobacco plant and the dust obtained during cigarette and the *bidi* manufacture go to waste. A process has been developed in the NCL using this waste as raw material for the preparation of an useful insecticide, namely, nicotine sulphate.

Cellophane-base or textile adhesive tapes are extensively employed in the packaging industry. An adhesive formulation and the method of manufacture of such tapes has been developed.

In the manufacture of metal cans required for the packaging of foodstuffs, the metal lid is often fixed on the body of the tin by means of a rubber-base gasket, called a can-sealing composition. A composition developed in the NCL has been found to be satisfactory and is now being manufactured in the country.

Use of ion exchange resins in water softening is now practised in many industries in India. A process for the manufacture of cation exchange resin for this purpose from cashew nut shell liquid was carried out on a pilot plant scale and is now being commercially produced. A process for the manufacture of polystyrene cation exchange resin has also been released to industry.

In textile industry, desizing of the fabric is necessary before it is subjected to dyeing and printing operations. An enzyme, called 'bacterial diastase', is employed for this purpose which does not weaken the strength of the fabric during desizing operation. In the NCL, an effective bacterial diastase has been produced by submerged fermentation, using cheap raw materials like groundnut cake and wheat bran and the process released to industry. At present the requirement of diastase is met by imports.

4-hydroxycoumarin is an important intermediate in the manufacture of some anticoagulant drugs, and modern rodenticide (Warfarin, Sintrom, etc.). A new and simple process for the manufacture of this key intermediate has been developed at the NCL and the synthetic drugs based on the same are being prepared by the industry. Many other synthetic drugs such as diethylstilbesterol, hexylresorcinol, etc., have also been prepared and the processes are being leased out.

A vegetable wax, having comparable composition and properties to imported carnauba wax, has been made by an economical process in the NCL from wastes of sisal plant (*Agave cantala*). The

sisal wax will be useful for the manufacture of polishing compositions for leather and metal and for the manufacture of carbon papers

Extensive pilot plant work has been carried out for more complex processes such as the synthesis of vitamin C from sorbitol, rayon grade pulp, chemicals from ethylene and methane, etc

The programme of the NCL is wide in its scope and supplements established technologies such as leather, glass, salt fuel, metal, food, drug, etc. It enjoys today a place of distinction among the research institutes on chemistry and chemical technology, not only in India, but in the scientific map of the world.

Acharya Jagadish Chandra Bose—His Life and Work (1858-1937)*

D.S. Kothari

Chairman, University Grants Commission, New Delhi.

ACHARYA Jagadish Chandra Bose occupies a high, almost unique, place in the recent history of Indian science. He was an investigator of uncommon courage, resourcefulness and dedication. Bose's scientific work broadly falls under three periods. From 1894 to 1899 he was almost entirely concerned with the study of electric waves; between 1899 and 1902 he shifted from the physical to the biophysical field, and beyond 1903 he was occupied with the study of plant-responses under physical stimuli of various types. For these studies he developed and constructed his own instruments which were remarkable for their originality and extreme sensitivity. Bose founded the Bose Institute in Calcutta in 1917 He continued to be the Director of the Institute till his death in 1937. Bose visited Europe many times, and America twice, on lecture tours. He was elected a Fellow of the Royal Society in 1920, and Corresponding Member of the Academy of Sciences, Vienna, in 1929. He was the General President of the Indian Science Congress in 1927. He served on the Council for Intellectual Co-operation of League of Nations from 1926 to 1930.

* * * * *

Bose was born on November 30, 1858, in the town of Mymensingh in East Bengal. (His father, Bhagwan Chandra Bose, was at the time Deputy Magistrate of the place) He died on November 23, 1937, at the age of 79 years. (He was survived by his wife Mrs. Abala Bose. She was the daughter of Mr. Durga Mohan Das, a leading advocate of the Calcutta High Court.) He received his primary education at the local school at Faridpur: his father did not send him to the English school which was there in the same town. Later, he joined the St. Xavier's School in Calcutta, and the College, from which he graduated at the age of 20. He subsequently went to England and joined the London University to study medicine. He attended some lectures by the famous zoologist, Ray Lancaster. Due partly to reasons of health, he left London to join the Christ College at Cambridge. He studied for the Natural Science Tripos, and attended lectures, amongst others, by Lord Rayleigh (Physics). He took the Tripos (Cambridge) and B.Sc. (London) in 1884. On his return from England he was appointed Professor of Physics in the Presidency College, Calcutta, in spite of serious opposition from the then Education Department. Bose had to do as much as 26 hours of lecture and demonstration per week. (This was much more than what was normal for his British

*Reprinted from *Proc. nat. Inst. Sci. India*, **24 A** (6) · 441-45, 1958

Acharya Jagadish Chandra Bose (1858-1937)

colleagues in the same college) He retired from the college in 1915

It was probably at the age of about 35 that Bose seriously made up his mind to dedicate himself completely to the pursuit of science and scientific research. No grant at the time was available to him for research work. The laboratory in the Presidency College, Calcutta, was poorly equipped and sometimes Bose had to construct his apparatus from his own personal resources. It was several years later that the Government sanctioned for his work in the college an yearly grant of Rs. 2,500. Bose's earliest research work was concerned with electric waves and their interaction with matter. Electric waves were first produced in the laboratory by Heinrich Hertz in 1888 in his epochal experiments. The existence of these waves had been predicted by Maxwell about 20 years earlier on the basis of his extremely far-reaching and extraordinarily fruitful (as later work showed) electro-magnetic theory. It has been sometimes said that Bose was led to the study of electric waves, after reading a paper by Sir Oliver Lodge on 'Heinrich Hertz and his Successors' (1894). From the very beginning Bose's remarkable physical insight, and his superb ingenuity and resourcefulness in experimentation were apparent He succeeded in generating waves of wave-lengths much smaller than what Hertz and others had done. He produced waves of about half-a-centimetre in wave-length. Because of this he was able to investigate in considerable detail the 'optical' properties of electric waves, such as refraction, polarization and double refraction. He determined the refractive indices of many substances and also investigated the influence on total reflection of the thickness of the air-gap between two dielectric slabs. In the paper published in the *Proceedings of the Royal Society* in November, 1897, he observed: 'It is seen from the above, that as the thickness of the air-space was gradually increased, the reflected component increased, while the transmitted portion decreased. Minimum thickness for total reflection was found to be 8 mm' He also verified that the thickness of the air-gap, for which total reflection disappeared, increased with the wave-length. It may be mentioned that Bose's first paper entitled 'On Polarization of Electric Waves by Double Refracting Crystals' (he tried beryl, rocksalt, etc.) was published in May, 1895, in the *Journal of the Asiatic Society of Bengal* In 1897 Bose gave a lecture at the famed Royal Institution, London It is interesting (and also instructive) to recall that the demonstration apparatus exhibited at the lecture, which in present-day terminology may be described as a (simple) microwave spectrometer complete with transmitter and receiver (improved type of coherer), was constructed in Calcutta and taken by Bose with him to London. The originality and simplicity of the apparatus employed by Bose in his experiments were most remarkable. For instance, he demonstrated the polarization of electric waves by the simple device of 'interleaving the pages of a Bradshaw railway time table with sheets of tin foil'. Again, to eliminate the undesirable reflections of electric waves in tubes employed to guide them (as in the case of spectrometer), he tried many different coatings—in other words, he was searching for an absorber of microwaves. He found that blotting-paper dipped in electrolyte gave the best results. 'Bose, in India between 1895-97, used hollow tubes of

either circular or square section as waveguides and waveguide radiators on wavelengths between 5 mm. and 2 5 cm. His adoption of hollow tubes was probably based on the use of metal tubes in telescopes and microscopes.'* Bose also employed conical horns—he called them collecting funnels—for concentrating the waves on the detectors He studied the rotation of the plane of polarization, and found that a bundle of twisted jute fibres gave right or left-handed rotation depending on the right or left-handed twist of the fibres. This constituted a 'large-scale or *macro* demonstration' of the optical phenomenon of the rotation of the plane of polarization.

For the detector, Bose used the coherer discovered by Branly and Lodge. He made considerable improvements, particularly in sensitivity and reliability. He also experimented with the point-contact-type detector consisting of a metal wire in contact with a metal plate or semi-conducting crystal. In the case of most substances, the resistance falls when the detector is exposed to electric waves but there is also a rise of resistance for some substances such as lead peroxide and potassium. Bose found that in the case of galena crystal the detector was not only sensitive to electric waves but also to light radiation extending from infra-red to violet. Here, he was obviously dealing with what later came to be recognized as photovoltaic effect. These experiments dealing with the variations in contact resistances under the influence of electric waves—particularly the erratic behaviour of the system in many cases—brought to Bose's mind the phenomenon of electric response in animal muscles when subjected to stimuli 'Bose enquires whether inorganic models may not also be devised which will satisfy this criterion. In this way he was able to construct models in which mechanical and light stimuli produce electrical responses. The proportionality which exists between intensity of stimulation and electrical response, the gradual appearance of fatigue in response after repeated stimulation, from which the system recovers after it is given sufficient rest, the increase of response on treatment with one set of chemicals and its inhibition by another set, are similar to what occurs in living tissues. We shall describe here only one of his models: it is made of two wires of pure tin, whose lower ends are clamped to an ebonite block, the upper ends pass through an ebonite disc, and are joined through binding screws to the two terminals of a sensitive galvanometer. The arrangement fits into a cylindrical glass vessel, filled with distilled or tap water. On giving one of the tin wires a sharp twist, an electric current flows from the wire through the galvanometer system. The amplitude of response is enhanced when a small quantity of sodium bicarbonate is added to the distilled water; on the other hand, if oxalic acid is added to the water the response is abolished. Many of the effects observed in animal tissues under stimulation, viz., of the opposite effects of small and large doses of a chemical poison, etc, could be obtained with this model of Bose.'** Mention here may also be made of the interesting analogy

* J F. Ramsay, 'Microwave Antennas and Waveguide Techniques [illegible] I.R.E., Feb, 1958.

**D. M. Bose, Jagadish Chandra Bose: [illegible] Science and Culture, 24, 5 (1958) p 215.

between the excitation of nerve and the passivity of iron dipped in strong nitric acid This was investigated in great detail by Lillie (1920-36) and later by Bonhoeffer.† The first suggestion came from W. Ostwald in 1901. Another interesting model is due to Bredig (1903-1908) in which the oscillations of a mercury drop placed in a hydrogen peroxide solution appear (outwardly) to resemble the rhythmic pulsations of an animal heart.

These investigations gradually led Bose to the formulation of his fundamental concept (and in this context it is relevant to call attention to his early training in physiology and medicine) that basically the response, under stimulus, in the non-living (e.g. metal) and the living (e.g. animal muscle) is of the same nature, though they differ in their level of complexity. From about 1903 onwards Bose investigated with great ingenuity, vigour and perseverance the response phenomena in plants when exposed to various kinds of stimuli, e.g mechanical, electrical and chemical, and also light radiation. He regarded that the response phenomena in plants lie between those exhibited in inorganic matter and in animals. He developed and constructed in his own laboratory special instruments for the purpose of measuring almost every type of plant response. The rate of growth of plants is, crudely speaking, of the order of 0.1—0 01 mm. per minute, and to measure that he constructed many instruments which he named *Crescographs* (*crescere* · to grow). The high-magnification *crescograph* consisted of a combination of levers (in some cases mechanical and optical) giving a magnification of about 10,000 The magnetic *crescograph*, in which the small displacement of a magnet caused a large deflection in a static magnetic system, produced a magnification of more than a million. Bose also developed several types of automatic recorders in which friction between the recording pan and the writing plate was eliminated by either vibrating the plate or the stylus. He constructed an instrument to record the liberation of oxygen during photosynthesis in plants. He also studied the variations, as a result of stimulations, in the electrical resistance of plant tissue. He was the first to use electric probes for the localization of actively metabolizing layers in plants.

Bose's plant work was largely carried out with the *Mimosa* plant and with *Desmodium gyrans* (telegraph plant, the Indian name is *bon charal*). He studied even such things as the effect of load (placed on the leaf) on response to stimulus. For instance, he observes: "The effect of load on the response of *Mimosa* is similar to that on the contractile response of muscle. With increasing load the height of response undergoes a progressive diminution with shortening of period of recovery Within limits, the amount of work performed by a muscle increases with load. The same is true of the work performed by the pulvinus of *Mimosa*.' In the case of *Desmodium gyrans* he observed that the detached leaflet continued to show rhythmic pulsations, the period being of the order of two minutes. The pulsation occurs between the temperature of about 17°C. and 45°C. The pulsation is affected by chemical reagents and electric stimuli.

† R. R. Bonhoeffer, 'On the Passivity of Iron'. *Corrosion*, **II** (1955). See also R Fatt, 'Physics of Nerve Processes'. *Reports on Progress in Physics*, **XXI**. (1958), P- 112.

Bose also investigated the problem of the ascent of sap in plants. He thought, contrary to the generally accepted view then and now, that this is brought about by peristaltic activity of the inner cortical cells in the plant stem, somewhat analogous to the activity of the animal heart.

* * * * *

It may be observed that one of the most far-reaching concepts which has emerged from the biological and physiological researches during the present century is that all vital processes in living organisms can be (completely) understood in terms of physical and chemical laws governing material phenomena. (It appears—some think it is certain that this is not likely to be the case in the realm of phenomena concerning the mind) Towards this realization Bose made a pioneering and very important contribution. In one of the papers read (but not published) before the Royal Society in 1904 he observed: 'From the point of view of its movements a plant may be regarded in either of two ways: in the first place, as mysterious entity, with regard to whose working no law can be definitely predicted, or in the second place, simply as a machine, transforming the energy supplied to it, in ways more or less capable of mechanical explanation. Its movements are apparently so diverse that the former of these hypotheses might well seem to be the only alternative. Light, for example, induces sometimes positive curvature, sometimes negative. Gravitation, again, induces one movement in the root, and the opposite in the shoot. From these and other reactions it would appear as if the organism had been endowed with various specific sensibilities for its own advantage, and that a consistent mechanical explanation of its movements was therefore out of the question. In spite of this, however, I have attempted to show that the plant may nevertheless be regarded as a machine, and that its movements in response to external stimuli, though apparently so various, are ultimately reducible to fundamental unity of reaction'.* And further, to quote from his book, *Plant Response as a Means of Physiological Investigation* (1906): "The phenomenon of life, then, introduces no mystical power, such as would in any way thwart, or place in abeyance, the action of forces already operative In the machinery of the living, as in that of the non-living, we merely see their transformation, in obedience to the same principle of conservation of energy as obtains elsewhere; and it may be expected that, in proportion as our power of investigation grows, the origin of each variation of the living organism will be found more and more traceable to the direct or indirect action upon it of external forces, the element of chance being thus progressively eliminated, as the definite sequence of cause and effect comes to be perceived with an increasing clearness; and only, I venture to think, as this is worked out, can we learn to apprehend fully the true significance of the great Theory of Evolution.'

* * * *

In his papers and books Bose gives very few references to previous and contemporary workers. This is partly, no doubt, due to the fact that he was in most cases exploring new ground. It should also be mentioned that 'the priority of many of Bose's observations, e.g. positive and

* 'Plant Response as a Means of Physiological Investigation' by Sir Jagadis Chunder Bose (1906), p. viii

multiple responses, alike electrical and mechanical, and transmission of death excitation, is seldom given the acknowledgement due, in current literature on plant physiology... He has left behind nineteen volumes which form a record of the work carried out and directed by him over a period of nearly thirty-seven years. Bose was truly a great man of science and his pioneering spirit and work have played a vital role in the revival of scientific research in our country. But for all this he was more in the nature of a lone worker—a towering but isolated peak—rather than a builder himself of a school of scientific research. To conclude we may quote his memorable words spoken at the end of the lecture at the Royal Institution (London) in January, 1897: 'The land from which I come did at one time strive to extend human knowledge, but that was many centuries ago. It is now the privilege of the west to lead in this work. I would fain hope, and I am sure I am echoing your sentiments, that a time may come when the East, too, will take her part in this glorious undertaking, and that at no distant time it shall neither be the West nor the East, but both the East and the West, that will work together, each taking her share in extending the boundaries of knowledge, and bringing out the manifold blessings that follow in its train.

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Geddes in his 'Life of Bose' gives the following extract from the *Spectator* (London): 'We can see no reason whatever why the Asiatic mind, turning from its absorption in insoluble problems, should not betake itself ardently, thirstily, hungrily, to the research into Nature which can never end, yet is always yielding results, often evil as well as good, upon which yet deeper inquiries can be based. If that happened—and Professor Bose is at all events a living evidence that it can happen—that would be the greatest addition ever made to the sum of mental force of mankind.'

Plan of a teaching unit —5. fish

The Fish are adapted for living in Water

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THE advantage of planning a science lesson effectively on the basis of unit approach to teaching science, hardly needs any elaboration It should be borne in mind while planning a unit in biological science that the central idea should be to assist the children in their own exploration of the living world. The subject should be exhibited inside the classroom in a situation as natural as possible and the children should be encouraged to observe nature beyond the school boundaries in their spare time.

An outline of a teaching unit on a topic suitable for class VI is suggested below to help the teachers in preparing the lesson. It might appear to the teachers that certain portions of this are slightly advanced for children of class VI But it should be borne in mind that the topic is of such a nature that once the teacher makes a begining of this, it is sure to open to the children a new avenue of interest. The children are likely to observe many things in the aquaria outside their class hours and would naturally like to have their doubts cleared by the teachers.

CONCEPT. FISH : The body parts of the fish are adapted for living in water. (*For Class VI*)

INTRODUCTION

Motivation Observation

Display around the classroom coloured pictures of different kinds of fishes. Let the children observe them carefully. Ask them to write down the characteristics which they find common among the various fishes.

Assist them in setting up an aquarium. Let them record their observations on (i) the movements of the fins in aiding the locomotion of fish (ii) the feeding habits of fishes.

Secure a large biological model of a fish. Collect the locally available fishes. Arrange a display of the preserved and stuffed fishes. Let them handle carefully and examine the fishes Ask them to note down in which of the features fish differ from human body and in which of the characteristics they are comparable.

Motivation · Discussion

Discuss the preliminary ideas and experiences that will form the background of the subject to ensure the pupils' motivation and enable their active participation in the discussion

1. What is an aquatic animal ? Give examples
2. Why do we drown in water ?
3. Why does a fish die when taken out of water ?
4. Why do the snakes and turtles living in water come up to the surface frequently ?
5. Why do whales send up a misty spray of water often ?
6. Why do boats and ships with lots of weeds attached underneath are not able to sail fast ?
7. How do certain small fishes introduced in wells, tanks and ponds help to keep down mosquitoes ?
8. Why does a fish farmer keep different kinds of fish in his pond ?

QUESTIONS AND PROBLEMS

1. How is the body of fish adapted for aquatic life ?
   a. What is meant by streamlined body ?
   b. What is the advantage to a fish of its streamlined body ?
   c. How are the scales arranged on the body of a fish ? What is the advantage of such an arrangement ?
2. How does a fish move from one place to another ?
   a. Are the movements of a boat and fish comparable ?
   b. What are the uses of the median fins in fish ?
   c. What are the functions of the paired fins in fish ?
   d. What role does the caudal fin play in fish ?
3. How are the respiratory organs of fish adapted for breathing in water ?
   a. Are the nostrils useful for breathing in fish ?
   b. Why does a fish open and close its mouth constantly ?
   c. What are the organs of respiration in fish ?
   d. How does the exchange of oxygen and carbon-dioxide take place ?
   e. Why and how are aquaria aerated ?
4. a. On what does a fish feed ?
   b. How are the mouth parts of fishes adapted for their feeding habits ?
5. What is a fish ?

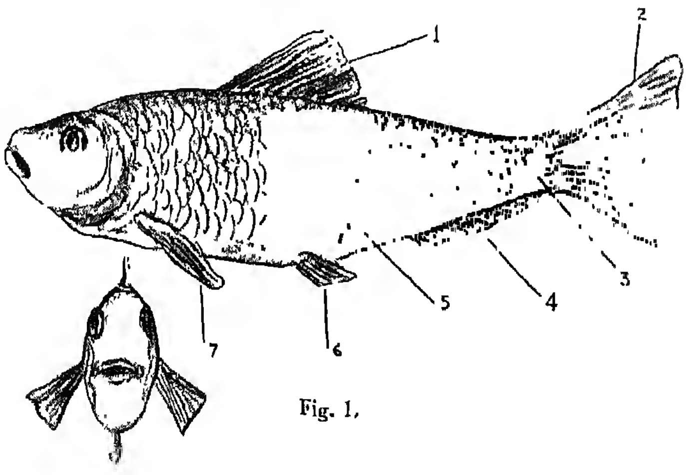


Fig. 1.

ACTIVITIES AND EXPERIENCES TO BE PROVIDED TO CHILDREN FOR UNDERSTANDING AND APPRECIATING THE CONCEPTS

1 *How is the body of a fish adapted for aquatic life ?*

a. What is meant by streamlined body ?

Examine the shape of a big dead fish and a model of a boat How are they shaped ? Are they comparable ? What are the similarities ? What is meant by streamlined body ? Conclude that the streamlined body is one which has pointed anterior and posterior ends and smooth sides

b What is the advantage to a fish of its streamlined body ?

How does the shape help a boat to cut through the water easily ? Why does a boat move with its pointed end forwards. Tie a rope to a small boat at its pointed end and pull it in water preferably against the current. Next tie the rope in the middle of its broad side and pull it. If a boat is not available, this can be tried with a toy-boat in a water tub. In which of the above two cases, is it easy to pull ? Why ? Do you understand as to what will be the disadvantage, if a boat is to move with its broad side forwards ? Have you ever tried to push a log of wood

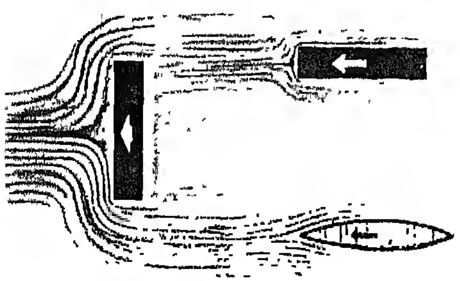


Fig. 2.

against the water current with its length at right angles to the current ? Why do you find it difficult to push it forward ? Is it not comparatively easy to push it with its length parallel to the current ? Why ? It will be much more easy if its anterior end is pointed and sides are smooth. Why ?

Have you tried to hold out and dip your hand in water from a fast moving boat ? Why do you feel the force of water against your hand even if there is no strong current ? Does it not indicate that the water is resisting the motion of your hand through it ? How does this resisting motion affect the objects moving in water ? What will be the result ? How to reduce this water resistance ? Deduce that this can be reduced by providing the minimum direct contact of the body against the resistance Recall how the water flows easily on either side of the anterior pointed end of a boat when it steers through the water. Conclude that the fish with its streamlined body offers the least resistance to the water through which it swims.

c. How are the scales arranged on the body of a fish ? What is the advantage of such an arrangement ?

Feel the surface of the body of a fish. How is it ? Rough or smooth ? How is the smoothness achieved in the fishes with scales ? Take a fish which has scales. Feel the surface of its body by passing your fingers from forwards backwards. How do you feel the surface ? What is the advantage of its smooth surface ? Pass your fingers in the opposite direction. What will be the disadvantage if the scales were to be directed forwards. Recall why we find it difficult to swim in water with our dress on ? Why

do we find it easy to swim with our bare body ?

2. *How does a fish move from one place to another ?*

a. Are the movements of a boat and a fish comparable ?

How does a fish swim in water ? How does a boat move in water from one place to another ? Have you noticed how the oars are flattened out at the ends ? Why are they flattened ? Have you noticed the ways in which the oars are used to drive the boat forwards ? Deduce that the *rowing* is one in which the boatman sits at the centre of the boat with an oar on either side *Sculling* is another in which the boatman stands at the back of the boat and moves an oar from side to side. How does the working of the

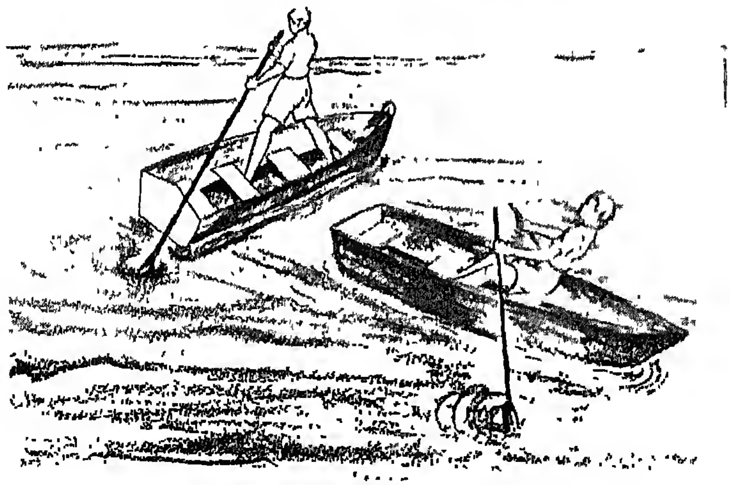


Fig 3.

oars push the boat forwards ? How does a motor boat travel without the oars ? What takes the place of oars in fish ?

Watch the movements of the tail of a fish in an aquarium, when it swims. Observe the tail curving to one side and then suddenly straightening. What will be the result if a series of such alternating

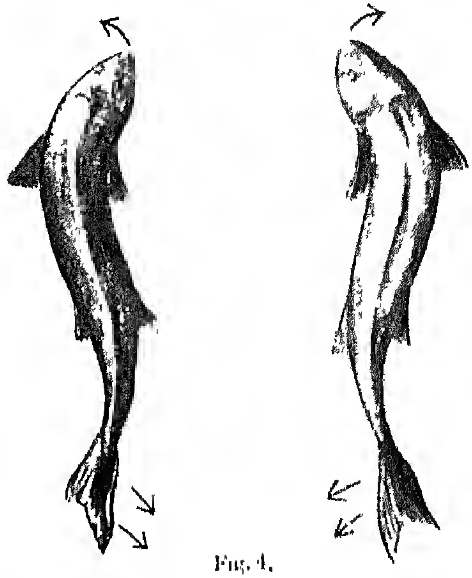


Fig. 4.

jerks are produced ? To which method of using the oars of a boat can this be compared ? Observe that when the tail is curved to one side the head is pointed slightly in the opposite direction. Deduce that this enables the fish to move in a straight line and not in series of curves.

b. What are the functions of the median fins ?

Count the number of fins in a fish. How many are paired and how many are unpaired ?

Observe the fins at the back and the fins below the belly of a fish. Watch their movements when the fish moves. Do they aid the fish in swimming ? To which part of the boat can these be compared ? Do you know which part of the boat is called the keel ? Why should the keel of the boat be high ? Deduce that the keel of a boat is for maintaining the balance.

How are the weights of a fish distributed on its body ? Which part of the body of a fish is heavy ? Head or tail end ? Dorsal or ventral side ? If an object moving under water, has more weight added to it in one place, how will it affect its movement ? Watch the demonstration of the under water movement of a toy-submarine. Add some weights in its anterior side what is the result ? Then add similar weight on its rear side, adjust it and observe. If the anterior part of the fish is heavy, in which part should we place more weight to bring about adjustment ? Deduce that the anterior part of the fish is relatively heavy. Instead of adding weights at posterior part of the fish, the straightened fins of fish act for stabilising the body. Conclude that the unpaired fins serve the purpose of stabilising the fish and to keep a straight course like the keel of a boat

c. What are the uses of the paired fins ?

When a fish moves fast, observe the position of the pectoral and pelvic fins. If the fins are folded against the body what does it indicate ? Watch the movements of these fins, when the fish just balances. Again observe the fins when the fish swims slowly. Observe that the tail does not perform its swift right and left side movements during this slow movement. What do you infer from this ? To which method of using the oars can this slow to and fro movements of the fins be compared ?

Take two cardboards as shown in Fig. 5. Fold your hands with the cardboards and run fast. While running suddenly spread the card boards as shown in the figure. Can you run so fast easily now ? If not, why not ? Observe the positions of the paired fins in a fish moving fast. When it suddenly halts, observe the positions of the paired fins. What do you infer about the uses of the paired fins from all these ?

Fig 5.

d. What role does the caudal fin play ?

Observe the movement of the caudal fin when the fish swims slowly. When does it make a full use of its movement different from the quick right and left movements of the whole tail? Watch the caudal fin bending to one side. What happens to the movement of the fish now? When the caudal fin of a fish is turned to one side, why does its body turn in the opposite side? What does a boatman do, to change the direction of his boat? To which part of the boat can the caudal fin be compared

3 *How are the respiratory organs of fish adapted for breathing in water?*

a. Are the nostrils useful for breathing in fishes?

How do we breathe? Where from do we get the oxygen for breathing? To which organ of our body does the air go? Examine the head of a dead fish. Where are the nostrils? How many are there? Dissect the fish and see where it leads inside. Find out whether it is connected to the respiratory organs. Conclude that though the nostrils are present in fish, they are not useful for respiration since they are not connected to the respiratory organs.

b. Why does fish open and close its mouth constantly?

Observe carefully a fish in an aquarium when it is not moving. Do you see that the fish is opening and closing its mouth constantly? Why does it do so? Since the fish is in water, what will happen when it opens its mouth? What happens to the water taken in, when the mouth is closed? Think about the two possibilities. Either it should enter into the alimentary canal or be expelled out.

Carefully observe the slit-like opening on either side of the head behind the eye. Do you find that also opens and closes constantly? Do you find, any correspondence between the opening and closing of the mouth and the slit? Observe

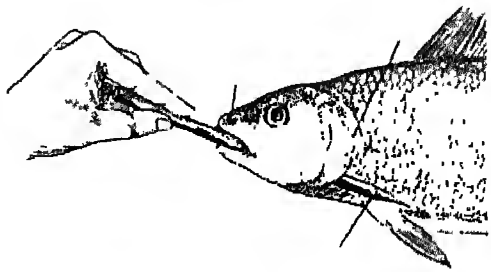


Fig. 6

the mouth when it opens. What is the position of the slit now? Next when the slit opens, observe the position of mouth. Deduce that when the mouth is open, water enters through it and when it is closed, the water is expelled through the slit.

c. What are the organs of respiration in fish?

Take a dead fish. Push a pencil through its mouth. Watch it coming out through the slit at the side? What does this indicate? Observe the interior of the slit, when it opens. What do you see

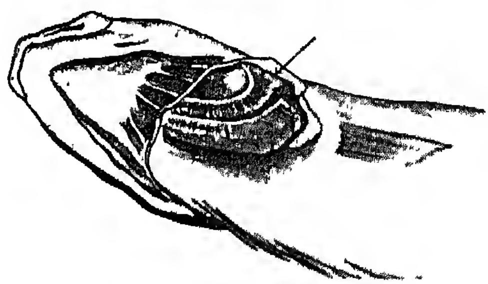


Fig. 7.

inside? What is its colour? Dissect out the head of a freshly killed fish and note the colour of these organs. Take

a spoiled or preserved fish and note the colour. Why is the difference in colour? Is the pink colour due to the presence of blood in it? Examine their structure and count their number Are these organs present in all the fishes you have examined? Conclude that these organs are gills and are present in all fishes.

d. How does the exchange of oxygen and carbon-dioxide take place ?

While diving under water or swimming how do we breathe? Does a fish come up to the surface to breathe air? Where from does it get the air? Take some water and heat it over a burner and observe. After sometime, do you see small bubbles coming out? Where from do they come? Why do they escape out while heating water? Where from did they enter into the water?

Dissect out a fish and find out which blood (arterial or venous) comes to the gills What is the nature of the blood going from the gills? If venous blood is brought to the gills, what is the gas dissolved in it? Does the water entering through the mouth, come in contact with the gills? The blood brings carbon-dioxide dissolved in it to the gills. But the blood going away from the gills is oxygenated or 'pure' blood. What do you infer from this? The water and the blood are merely separated by a thin membrane. What do you understand from this? What is the process called, when oxygen is taken in and carbon-dioxide given out in a living body? Conclude that the fishes respire the oxygen dissolved in water through their gills.

e. Why and how are aquaria aerated ?

Why do large number of fishes die when too many are kept in a small aquarium? Take two wide mouthed bottles. Into one pour cold water and introduce a fish. Into the other bottle pour recently boiled and cooled water. Introduce a similar fish into this also. Close the mouths of the bottles with lids. After sometime count separately how many times a minute fish in each bottle breathe? Do you find any difference in the rate of breathing? If so, Why? Take out the bottle No. 2. Put some green plants and leave it in mild sunlight. Count the breathing rate after sometime Do you find any difference between the previous and present rates of breathing? If so, why? Why should aquaria have large surface of water exposed to atmosphere? Select two bottles of identical dimensions. One should be wide-mouthed and the other narrow-mouthed. Put 2 or 3 similar fishes in each. After a day count the rate of breathing of the fishes for each bottle. Do you find any difference? What is the reason for it?

4. a. On what does a fish feed ?

Do all fishes eat the same type of food? Try different kinds of food materials like worms, mosquito larvae, cooked rice, pieces of algae, etc., in an aquarium in which many kinds of fishes are kept. Classify them according to the food they eat as carnivorous, herbivorous and omnivorous. Conclude that the food habits of fishes differ.

b. How are the mouth parts of fishes adapted for their feeding habits ?

Observe the feeding habits of the fish called murrels in an aquarium devouring small fishes. Deduce that the murrels are carnivorous fishes. Examine their mouth, jaws and teeth. Why are their jaws very strong and prominent and their mouths wide? Do they chew their

prey? If not, how are the teeth useful? Examine the teeth of sharks. Why are they curved inwards? Conclude that in carnivorous fishes the teeth are useful for firmly gripping the prey and prevent their escape out of their mouths and the wide mouths enable them to swallow the whole prey easily.

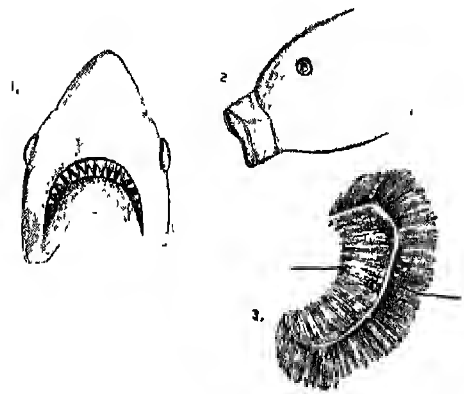


Fig. 8.

Filter the minute organisms found in pond water and put them in aquaria Watch the fishes feeding on these. How do they drain away the water alone and retain these small organisms? Examine their filtering device. Do you find these in carnivorous fishes? If not, why not?

Observe how gold fish and mullet feed? Why do they scoop up the mud frequently, churn them and spit them out? How are the snouts adapted for this? In contrast to the carnivorous fishes how are the mouths in these fishes?

5. *What is a fish?*

Is there a backbone for a fish ? What is an animal with backbone called? What is its habitat? Deduce that fish is an aquatic vertebrate. Are all aquatic vertebrates fishes? Whale lives in water. Is it not a vertebrate? Is it a fish? Are aquatic snakes vertebrates? Why are they not included among the fishes? How do the above animals breathe? How does a fish breathe? Deduce that a fish must have gills. Do the tadpoles possess gills? Is it a fish? If not, why not? Conclude that fishes are permanent aquatic vertebrate breathing by means of gills.

CULMINATING ACTIVITIES

The following trips can be arranged.

a. A trip to an aquarium to aquaint the children with the organization and maintenance of aquaria with particular emphasis on the circulation of water, aeration, lighting arrangement, setting up of the aquarium, collection and handling of fishes, feeding and breeding techniques, etc.

b. A trip to the fishing club to demonstrate angling as a leisure time activity.

c. Visit to a museum to observe the varieties of fishes, order of arrangement, display, etc.

d. Visit to a boat building yard or boating club to learn the different parts of a boat and different types of boats and to watch the demonstration of rowing, sculling, etc.

Before taking the children they must clearly know what to look for, where and how to search. They must also be taught about the techniques of planning and proper conduct in the public places, etc. The children can report their findings in the classroom and the teacher can discuss them, summarize them on the blackboard and link them with the study programme.

Answers to Questions and Solutions to Problems : Concepts

Functional knowledge of facts, concepts and principles	*Objectives*	*Learning Experiences*
1. The smooth streamlined body of a fish makes its movement in water easy	Experience contributing to the concept of existence through adaptation	Visit to aquarium and museum to observe the streamlined shape of different species of fishes.
a. Streamlined body is one which has pointed anterior and posterior ends and smooth sides	Developing better understanding of the basic science principles underlying common natural phenomenon	Collection and examination of the models of different streamlined objects of our every-day life like ships, boats, aeroplanes, cars etc.
b The streamlined body offers the least resistance to the water through which fish swims.	Realization of the principle found in nature and their application in our everyday life.	Display of coloured charts of fishes with streamlined body
c. The scales are arranged with free ends directed backwards. The smooth surface and the non-wetting property facilitates the movements of fish in water with greater ease.		Examining the arrangement of the scales on the body of recently dead fishes.
2 Fish moves from one place to another with the help of its tail and fins.	Appreciation of the role of observation in science for drawing conclusions.	Watching the movements of fish in aquarium.
a Sculling a boat and swimming movement of a fish are comparable.	Understanding of the principles found in nature and their application of these phenomenon. in our life	Visit to a boat club and see the demonstration of using the oars in different ways.
b The median fins of fish are for stabilizing the fish and to help a straight course.	"	Observation of the movements of fins in aquaria.
c. The paired fins help to balance the fish and further assist in the forward movement carried out by the tail	"	"
d The tail fin is useful for changing the direction of the movement like the rudder of a boat.	"	"
3. The respiratory organs of fish are adapted for respiring the oxygen dissolved in water.	Experience contributing to the dependence of living things on water	"
a. The nostrils though present in fishes are not useful for breathing. They end without any connection to the respiratory organs.	Creating ability to search and find for themselves the facts.	Dissection and observation in a preserved or dead fish of the position of nostrils, size etc.

Functional knowledge of facts, concepts and principles.	*Objectives*	*Learning Experiences*
b Fish opens and closes its mouth frequently to enable the water enter its mouth and flow over the gills.	Development of the power of observation and reasoning.	Observation in aquarium.
c. Gills are the respiratory organs of fish and they are characteristic of all fishes.	Encouraging the formation of generalizations from observed functional informations.	Dissection and examination of the location, number and arrangement of gills.
d Exchange of gases takes place in the gills by diffusion.	——	
e. Aquaria are aerated to replenish the oxygen used up by fishes The plants in the aquaria replenish the oxygen to a certain extent through the photosynthesis. Air can also be bubbled into the aquaria. But the major exchange of gases takes place through the contact of water with the atmosphere.	Experience contributing to a concept of the interrelationships of living things Development of a new avenue of enjoyment and education for leisure or during vacation.	
4 a. Different fishes feed on different food materials.	Appreciation of the exploitation of this knowledge in commercial fishing.	Dissection of the stomachs of the fishes and analysis of the food materials.
Some are carnivorous, some herbivorous and some omnivorous.	"	
b. Carnivorous fishes have wide mouths with teeth to bite the prey and swallow and to prevent its escape.	"	Examination of the mouth parts of fish like teeth, jaws, snout etc.
c. Fishes feeding on minute food particles have filtering device.	Understanding of the science behind the fish farmer stocking the ponds with different kinds of fishes.	Feeding with different food materials and observation of the ways of feeding in aquaria.
d. Fish feeding on the bottom materials have protrusible snout to help in shovelling the soil.	"	——
5. Fish is a permanent aquatic resident. It is a vertebrate breathing by means of gills	To introduce the concept of classification of animals.	——

The children can arrange a small school exhibition taking the help of the authorities of the museum, fisheries department and fishing club to stimulate the interest in others about the wonders of fish life.

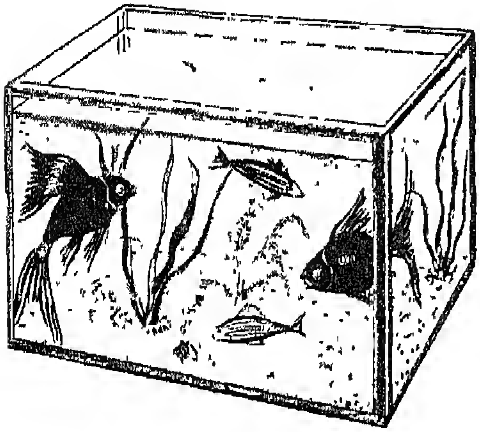


Fig. 9.

NEW QUESTIONS

1. Why does a fish float belly side up when dead ?
2. Why do people look into the gills of fish before purchasing ?
3. Why do you use bait in the hook while angling ?
4. Can a fish drown ?
5. Why do you keep an aquarium with plants, near the window ?
6. How does a king-fisher swallow a fish—head first or tail first ? Why ?

RELATIONSHIP WITH OTHER SCHOOL WORK

1. Relate language with teaching of writing letters requesting permission for visits, and for thanking them.
2. Relate teaching of craft with making of models connected with the topic.
3. Relate drawing with the figures of fishes

RESOURCES

Books

1. Beggs, D. *Nature Study*, Department of Education, Wellington, 1951
2. Commonwealth of Pennsylvania, Department of Public Instruction, Harrisburg, *Course of Study in Science for Secondary Schools*, Bulletin 100 A Progress report 1951.
3. Croxton, W.C. *Science in the Elementary School*, McGraw-Hill Book Company Inc. 1937
4. Cimbs, Alice M. *Living things. How they move* (part 2) *How they breathe and feed* (part 3) Chatto Windus London
5. Heiss, Elwood D., *et al.* *Modern Science Teaching* Macmillan Company, New York, 1950.
6. Tyrer, F. *Discovering Biology* (Book 2), *Energy of Life*, Longmans, 19[illegible]
7. UNESCO Source Book of Science Teaching (Unesco) 1954

Films.

1.	Beginning Swimming	English	11 mts.
2	Fishing thrills ...	do	10 mts.
3.	How animals move ..	do	10 mts.
4	Underwater spear fishing	do ..	11 mts.

Classroom experiments

Air has weight

DOES air have weight? This can be verified by doing the experiment suggested here. Improvise a balance out of a metre stick. Bore three holes one at each end and one in the middle of a wooden metre stick. The middle hole should be slightly at a higher level than the midpoint. Pass a string through the middle hole and suspend it from a nail or hook. Suspend an inflated balloon by a thread passed through the other endhole. Add paper clips till the weight of them just counterpoises the weight of balloon with air. Now when it is balanced nicely, prick the balloon with a sharp needle. When the air has escaped observe which side of the balance goes down due to more weight. Discuss why this should happen. When the air from the balloon escaped, it became lighter and the metre scale tilted down towards the end with the clips. This experiment clearly shows that air has weight. (Adapted from *General Science. Handbook of Activities*, NCERT, 1964. Unit I, Class VI, Concept 2-b.)

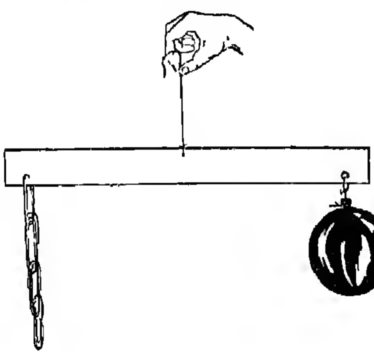


Fig. 1.

AIR PRESSURE MAY BE MEASURED BY VARIOUS HAND MADE BAROMETERS

Stretch a sheet rubber over the mouth of a small glass jar or wide-mouthed bottle. Wind a thread over the neck of the bottle tightly to secure the rubber. With a little household cement or tape seal the edges of the rubber, after trimming off the edges. Cut a thin circle from the end of a cork and glue it to the centre of the rubber. Then glue a long broom splint on the cork to serve as a pointer. Make a fulcrum by sticking a match stick on the shoulder of the bottle with sealing wax (Fig. 2). Fix an arc cut from a cardboard to serve as a scale. You now have aneroid barometer (Adapted from *ibid.* Unit I, Class VI, Concept 3-a).

A COVER CROP PREVENTS LEACHING

To show that a grass cover will lessen the extent of leaching, do the following experiment.

Take two flat enamel trays or flat tins (without lids). Cut out one edge and replace it with wire-netting. Fill one tray

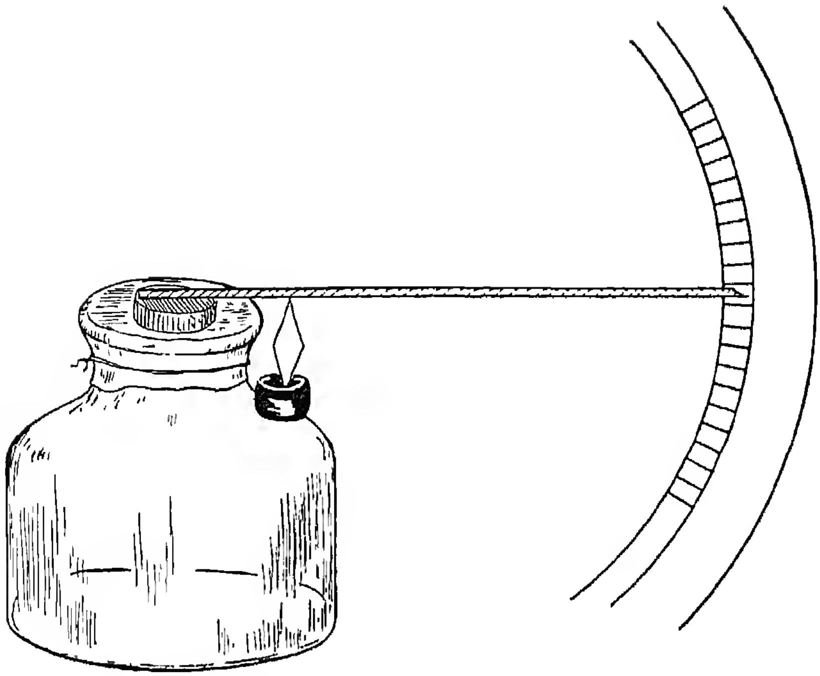


Fig. 2.

with garden soil and the other with an equal amount of sod (grass growing in soil). Place the trays on two beams of wood so that they are gently sloping.

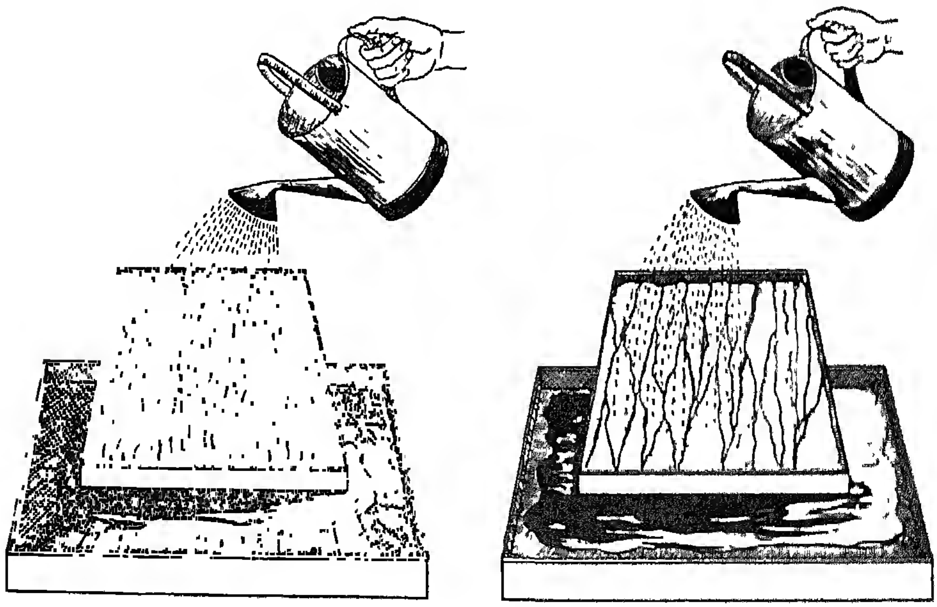


Fig. 3.

Place two other trays at the lower end of each tray. Now pass a measured quantity of water through the rose of a watering can. Pour equal quantities of water on each tray. Collect the water that comes out. See which tray allows more water to flow through it. See also by the mud in the water which tray loses more soil. (Adapted from *ibid.* Unit II, Class VIII, Concept 2-c).

SLOW OXIDATION PRODUCES HEAT

Take two thermos flasks. In one place two cupfuls of soaked bean seeds. Seal the top with a cotton plug and insert a thermometer to register the temperature. In the second thermos flask put dry seeds. Seal and insert a thermometer in this also. By watching over several days and observing the changes in temperature, it will be seen that heat energy is produced by the slowly germinating seeds.

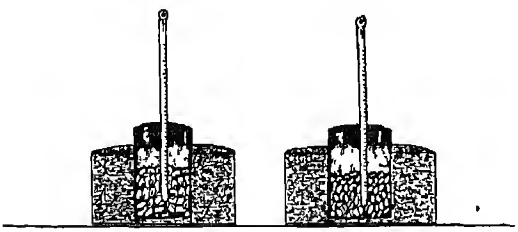


Fig. 4

If thermos flasks are not available a suitable insulated container can be made by using a small tin or bottle inside a larger tin with the space between filled with saw dust or other insulating material. (Adapted from *ibid.* Unit III, Class VII, Concept 1-a, b.)

RELATIONSHIP BETWEEN PLANTS AND ANIMALS AND AIR

Animals use oxygen from the air and plants produce oxygen. The experiment described here is to demonstrate the dependence of plants and animals on each other in their use of some substances from the air. This experiment is similar to the one done by Priestley and other scientists.

Take 30 ml of water in each of four 100-ml beakers. Take four test tubes. Into one test tube place a piece of filter paper or cotton wool moistened with sugar solution. Do not touch this filter paper or cotton with your fingers, but place them with a forceps almost at the bottom.

Prepare a small ball of paper to form a plug which is not too tight nor too loose but will just stay in the place where it is placed. Remove the plug and insert a fly already captured into the test tube. (Caution: Do not injure the insect) Insert the plug and thrust it to about half way down the tube. This plug is to prevent the fly from escaping. Invert the tube and dip the open end into the water in one of the four beakers earlier prepared. Lean the tube on the wall of the beaker (Fig 5). Let us call this Tube No.1.

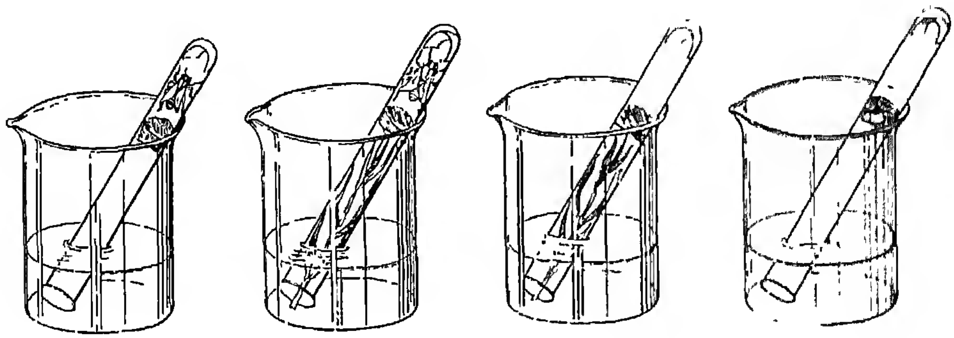
Now prepare the other three tubes in a similar manner but with some variations as described below

Tube No 2. In addition to the preparations done for tube No. 1 insert a green leafy shoot into the tube with its top almost touching the paper plug and its cut end dipping in the water in the beaker. Thus this tube will have both the insect and the shoot

Tube No.3. Repeat the procedure that was adopted for Tube No. 2 but omit inserting an insect.

Tube No.4. Repeat what you did for Tube No.1 but omit the insect. This

tube will have neither the insect nor the green shoot. *What is the function of this tube?* Thus Tube 1 has the fly alone, Tube 2, fly and the shoot, Tube 3, shoot alone and Tube 4 neither



1 2 3 4

Fig 5

When all the four tubes are prepared and set in good light, the experiment is begun. Two sets of observations can be made (i) How long the insects in Tubes 1 and 2, live, (ii) the changes in the volumes of gases in each tube.

I. Make observations at various times of the day to see when the insect in either of the two tubes dies first. *Explain why the insect in one dies while the one in the other survives.*

II. Changes in the volume of gas in each tube and the substances used or produced by the organism in each tube.

Mark the level of the air column on the outside of the test tubes with a glass writing (wax) pencil. Measure the length of the air columns in the tubes in millimetres. Observe the tubes periodically and when the fly in Tube 1 dies the experiment is over.

Measure the length of the column of gas in Tube 1. *Note the amount of increase or decrease as percentage of the volume measured in the beginning. How could you determine what gas has been produced by the fly?*

Add two pellets of sodium hydroxide to the water in each of the beakers. Use a spoon or forceps when handling sodium hydroxide and do not touch it with your hands. Mix with a glass rod, without removing the test tube out of the water in the beaker. The sodium hydroxide dissolves in the water and this solution is a better solvent for carbon-dioxide than is water. With this explanation in mind explain the change in the water level, if any, in the test tube, which will probably occur as the NaOH dissolves.

Draw conclusions from your observation regarding Tube 1. Repeat the observation concerning the other tubes. What factors might explain any observed changes in volume in Tube 4. How would changes in volume in Tube 4 affect your interpretation of the changes in Tubes 1, 2, and 3.

In a short paragraph, give an organized summary of the conclusions from the observations made in this experiment.

(Adapted from *Student Laboratory Guide, Biological Science - An Enquiry into Life.* Harcourt Brace & World Inc., New York 1963 B.S.C.S. Yellow Version).

Science abroad

Nuffield Foundation Science Teaching Project

THE Nuffield Foundation in England has for some time been interested in helping to improve the teaching of science in schools. It has had in view not only the new proposals for G.C.E. examination syllabuses drawn up in 1961 by the Science Masters' Association and the Association of Women Science Teachers, and the work on curricular reform initiated in the same year by the Scottish Education Department, but also the science teaching projects conducted in America under the National Science Foundation, the series of conferences on the teaching of science organized by O.E.C.D., and many similar ventures in Britain and overseas.

Against this background of activity, the Foundation decided in December 1961 that it would now be in a position to further in a practical way the reform of science curricula in Britain. In that month the Trustees agreed to set aside an initial £250,000 towards a comprehensive long-term programme.

Aims

The central objective of the Nuffield Foundation Science Teaching Project is 'science for all'—not merely for the future specialist but for the future citizen in the latter half of the twentieth century. The programme has been designed initially to concentrate on four broad sections: physics for 11–16-year olds, chemistry for 11-16-year olds; biology for 11-16 year olds; and science for 8-13-year olds in primary schools and non-selective secondary schools.

The aim in the first three sections is to provide an integrated range of tested teaching resources in physics, chemistry and biology, designed by teachers for teachers. The material is being designed to be equally suitable for future science specialists and for those who later specialize in other subjects or who leave school at the age of 16. It will be intended primarily for use in the first four or five years in grammar schools and the upper streams of secondary modern schools, and will offer to all who might normally study for the G.C.E. 'O' Level (or Scottish 'O' Grade) examinations some insight into scientific thought and method. The appropriateness of the material for those pupils likely to sit for the new Certificate

Paper presented at the Commonwealth Conference on the Teaching of Science in Schools, held in Peradeniya, Ceylon in December, 1963.

of Secondary Education will, however, also be carefully investigated.

Organization

The programmes are based upon, and are intended to consolidate, the work which has already been done, in Britain and elsewhere, in revising school science curricula. The Foundation is acting as prime sponsor and co-ordinator but is collaborating fully with other interests in the field.

In physics, chemistry and biology a full-time organizer has been appointed to lead the work of each section and has been seconded to the Foundation's staff for the necessary period. Each organizer is backed by a consultative committee, bringing together a wide range of expert knowledge in the subject. Detailed work on each programme is being undertaken jointly by the organizer and teams of practising teachers, with team leaders seconded full-time for at least a year.

The range of resources in each section will include teachers' guides, class texts, laboratory notes, apparatus and visual aids such as films, filmstrips, charts, illustrations, and models. The material will be tried out under classroom conditions and modified in the light of this practical experience before being made generally available. The end products are planned to take the form of co-ordinated sets of material to be used by individual teachers as they think best.

The Foundation makes the necessary arrangements to familiarise teachers who are involved with the preliminary trials of the material, with the new teaching approach.

Time-table

The intention is to have the range of teaching resources in physics, chemistry and biology ready within two or three years for production on a scale sufficient to meet the expected demand.

The Physics section was inaugurated in May, 1962 under the leadership of Mr. Donald McGill. It suffered a severe setback in his tragic death on the 22nd March, 1963, but arrangements have now been made to continue and complete the work, in the spirit in which he initiated it and in the direction he foreshadowed, under the guidance of Professor Eric Rogers as organizer, and Mr. John Lewis as associate organizer. The initial phase of drafting the teachers' guide for the five-year course, and preparing the apparatus likely to be required for the scheme, is now at an end. Preliminary trials of different complete years of the course will take place between September 1963 and July 1964 in sixteen schools, with further trials of individual topics in a number of additional schools. During the coming year work will continue on the preparation of pupils' texts and other written material, and the production of visual aids. It is hoped that the whole range of materials will be available in preliminary form by September 1964, in time for a more extensive series of classroom trials.

The Chemistry section began in September, 1962 with the appointment of Mr. H.F. Halliwell as its organizer. During the first year the teams have concentrated on the preparation of materials for trial (including a teachers' handbook of a sample five-year scheme, pupils' texts and background readers, and a book of data). It is planned to try out various parts of the course in schools from January 1964 onwards, and to continue revising and retesting during 1964 and 1965.

In the Biology section, which got under way in January 1963 under the leadership of Mr. W H Dowdeswell, the first aim has been the preparation of a teachers' guide and pupils' text for an experimental one-year course This course, based largely on a physiological approach and concerned mainly with topics which occur in existing G.C.E. 'O' level syllabuses, is being tried out in over fifty selected schools during the current school year Further short courses on genetics and evolution and microbiology will also be tested during the autumn of 1963. Work on the remainder of the five-year course is proceeding and it is expected to complete the draft material and the accompanying visual aids in time for extensive school trials of different stages of the whole course during 1964-65.

Work on the Science section is concerned with introductory science (intended for 8 to 13-year olds in primary and secondary modern schools) It is also hoped to embark on a comparable scheme for mathematics for 8 to 13-year olds in the coming year.

Other sections of the general programme may ultimately include physics, chemistry and biology for 16 to 18-year olds intending to become science specialists, science for 13 to 16-year old pupils of less than average ability; science for non-specialists in the sixth form, and a physical sciences/biological sciences course for 11 to 16-year-olds, as a more satisfactory alternative to existing general science courses

Underlying Objectives of the 11-16 Programme

In this 11–16 science programme considerable importance is attached to the participation of experienced teachers of science, who have the necessary insight into the interests and capacity of 11–16-year old pupils to ensure its success It is important to bear in mind the pupils' view of the subject, to make science intellectually exciting for them, and to bring them through their own investigations and arguments to an understanding of what science is and, as far as possible, of what it is like to be a practising scientist. (It must also encourage them, incidentally, to express their understanding in a clear and effective way.)

The main objective then is concerned with education in its broadest sense. The challenge is not only to provide an intellectual discipline valuable in its own right but to encourage an attitude of critical enquiry, an ability to weigh up evidence and assess probabilities, and a familiarity with the main principles and methods of science.

The implications of this central objective are perhaps obvious but nevertheless worth stating. For if the main emphasis is on the achievement of an understanding deeper than the mere ability to repeat what the pupil has been carefully instructed to repeat, then the approach to the subject must change accordingly. Rather than being told all the answers, the pupils must be given time and opportunity to learn by working out scientific problems for themselves.

Such an approach, desirable as it is, brings with it certain difficulties. First, for the teachers who (largely because of the pressure exercised by the examinations) may be unfamiliar with this approach and, perhaps, apprehensive of the difficulties they think they foresee in having to adopt radically different classroom methods. Second, for the teachers who, while they are sympathetic to these ideals,

greater depth of understanding, and a greater sense of excitement and intellectual discovery, will nevertheless, be well worth the price.

Now how are the practical problems of the changes of classroom practice, the additional effort demanded by pupil and teacher, and the shortage of time to be met? We do not yet know the full answers, but some general indications can be given. First, the unfamiliarity of approach may be alleviated by a very full teachers' guide offering suggestions for (and sometimes detailed guidance on) classroom and laboratory practice, together with introductory courses for those teachers intending to adopt the scheme. Secondly, the burden on teacher and pupil may be lessened by a carefully planned approach, in which new themes and concepts are introduced gradually and returned to again and again with an increasing degree of sophistication. Thirdly, the pressure of time may be reduced by pruning some familiar items, by a more effective (and thus ultimately quicker) presentation of the items which remain, and by a complete thinking of the aims, purposes and treatment of the final examination.

Teachers' guides and courses will suggest ways for teachers to promote in the classroom and laboratory an attitude of enquiry, an ability to assemble the relevant evidence (sometimes at first-hand by the pupil's own experiment, sometimes at second-hand from the experiments of others), and a further ability critically to study the implications of this evidence.

The planning of the teaching approach is not a mere matter of compiling a syllabus. A bald list of topics may be interpreted (and misinterpreted) in many ways, and cannot itself show the gradual unfolding of ideas in the kind of teaching intended. The need is rather to indicate, through the teachers' guide, the pupils' texts, the laboratory notes, and the accompanying visual and practical materials, reliable ways of promoting a sound understanding of the topics to be covered. In each section of the project, the organizers have chosen to begin with an introductory phase (which in physics and biology will last two years and in chemistry probably three) in which the pupils are encouraged to look more closely at their familiar surroundings and to think more carefully about their familiar experiences. At this stage they make a first— and necessarily superficial acquaintance with many of the ideas which they will later study in more detail. As time goes on, their treatment of these ideas becomes increasingly analytical experiments take on a more quantitative aspect, and models and theories are gradually built up to account for phenomena already established in the pupils' experience.

No pretence is made that, within the normal school time-table, the whole field of scientific discovery could be treated in this way. In all three sections physics, chemistry and biology only selections from the whole can be offered: but offered, it is hoped, in such a way that at the end of his five-year course the pupil himself will want positively to find out more, and will be intellectually equipped to do so. The main principle of selection, clearly, will be the relevance of each topic to a coherent and effective understanding of science as it is today (or rather, when we are aware of a shift in the main centres of interest, as it may be ten years hence). Thus, the various schemes may well

recognize how rewarding they might be, believe that their adoption would put an impossible burden on their shoulders. Finally, for the many good teachers who, while they have already attempted this approach whenever possible, find the existing system allows them too little time to do so effectively. The approach must be equally demanding and stimulating for the pupils who, instead of being always provided with ready-made answers in the classroom, and sequences of clear instructions in the laboratory, would find themselves having to do some independent thinking and reasoning in the face of challenging questions, and having to carry out experiments on their own, learning by mistakes and being encouraged by successes. While such an approach will certainly make demands on both teacher and pupils, the benefits in terms of a certain new material which has hitherto not been covered in the usual G C.E 'O' level syllabus—for instance, aspects of nuclear physics, an introduction to genetics and evolution, and a consideration of the energy changes that accompany material changes To make room for this new subject-matter as well as to leave more time for the adequate study of important traditional themes, many familiar (and perhaps sometimes favourite) topics will have to be omitted, or at least kept only as optional extras for the faster pupils.

If time is to be saved by streamlining the presentation wherever possible, and if emphasis is to be placed on understanding rather than on mere factual knowledge, the whole purpose and nature of practical periods has to be re-examined. Simple and effective pupils' experiments and teachers' demonstrations must be devised, and in all three subjects a certain amount of new apparatus may be called for. It must be stressed, however, that the amount of completely novel material will be only a small proportion of the whole · for science, after all, is not a new subject, and much of it is already taught in every school. The main novelty of the scheme lies not in its particular choice of content, which is relatively unimportant, but in its whole approach.

The three organizers are unanimous in agreeing that no syllabus, in the sense of a bare list of subjects to be covered, should be published in isolation from the whole range of teaching material. This is because the issuing of a syllabus focusses attention on questions of content, and so distracts from the main issue.

Finally, the project sharply recognizes that the scheme cannot hope to survive, however good it may prove to be, unless pupils who have followed its course are able to take a form of public examination which is itself in tune with the whole approach. Given our general aims, and the methods we suggest for promoting them, we cannot merely offer the examining boards a new syllabus, for this would solve few of the problems which we are attempting to tackle. What is needed is a series of specimen papers which, like the end-of-term tests suggested at each stage of the course, the exercises set each week for homework, or the questions posed each period in class, must be designed to encourage carefull thinking and to look for sound understanding, not simply to check the pupils' aptitude for total recall. This, too, is far easier said than done. but because it is a problem as vital as it is difficult, each organizer has appointed a special team to devise any try out new

forms of examinations which reflect the attitude and pattern of the course itself. During the trial phase, such sample examination papers will be set and marked, and then revised and improved upon; and once their practicability has been reasonably demonstrated, examining boards will be asked to consider setting alternative papers on the suggested pattern.

(To be continued)

Recent Developments in Science Teaching in Scotland

Arthur J. Mee

DURING the last three years there has been in Scotland a complete appraisal of the aims of teaching science and the content of the school science syllabuses Scottish secondary education begins at the age of about 12 and consequently pupils in Scotland start their secondary course one year later than their companions the England. Pupils following a certificate course (of whom 35 per cent follow an academic course) can take the Ordinary Grade examination at the end of their fourth year and the Higher Grade at the end of their fifth. The better pupils are encouraged to by-pass the Ordinary Grade examination and aim directly at the Higher Grade, but only a minority do so. Thus the Scottish pupils have only four years of secondary education before they face the Ordinary Grade examination, as compared with five in England and the examinations in the two countries are roughly of comparable standard. The standard of the Higher Grade is about half way between the English Ordinary and Advanced Levels (although it is not possible to make an exact comparison) The possession of a certain number and group of Higher Grade passes qualifies a pupil to admission to a Scottish university, but it does not follow that a candidate with these minimum qualifications will be admitted to the faculty of his choice. The various faculties have their own requirements over and above those required for university admission. Many pupils now stay on for a sixth year but very few remain for a second year in the sixth which is the general rule in England. In the sixth year some take University Bursary Examinations corresponding in some ways to Advanced level examinations, although it is difficult to compare them; a few take the advanced level examinations of the English Boards; but the majority spend their time taking more subjects on the Higher Grade and thus improving their certificates In only a very few schools is the sixth year regarded as one in which pupils will be allowed to broaden their experience by studying subjects of their own choice.

All pupils who enter the secondary school (at the age of 12) have science in their curriculum for the first two years. The aim is to provide a general background of scientific knowledge in physics, chemistry and biology. However, biology is frequently the most neglected of the branches at this stage.

At the end of the second year, a number of pupils drop the study of science altogether. These are not necessarily the weaker pupils. Many of them are able boys and girls who wish to concentrate on other branches of study and who discontinue science merely because they do not have the time for it.

Paper presented at the Commonwealth Conference on the Teaching of Science in Schools, held in Peradeniya, Ceylon in December, 1963.

The others go on normally to study two branches of science, the most popular being physics and chemistry. Thus they have two years of more detailed study before the Ordinary Grade examination. Some take no more science than this, while others carry on with the subject to the higher grade to study science at the university or college of Further Education or to obtain a higher pass in the subject to complete the requirement for university entrance.

EXAMINATION SYSTEM

The Examination system in Scotland differs fundamentally from that in England in that there are no examination Boards. The examination for the Scottish Certificate of Education is conducted by the Scottish Education Department, who are responsible both for the syllabuses and for the question papers. No fees are charged, the whole cost being met from public funds. The Secretary of State conducts the examination under authority derived from the Education (Scotland) Act, and he is answerable to Parliament for its proper administration. Although the Department are responsible for devising the syllabuses, the teachers' organizations and other interested bodies are always fully consulted before any major change is made either in syllabuses or in organization. These bodies also comment on the papers after the examination, and great regard is paid to their comments in the framing of papers for the next examination. This has made it possible for the Department to bring about changes in the value of the work done in the school, and to bring about the reference which many people felt to be desirable, much more quickly than would have been possible otherwise, simply by offering a new examination based on the new syllabuses as an alternative to the existing examinations based on the traditional syllabuses. This encouraged science teachers to modernise their teaching, because they knew that their pupils would not be prejudiced at the examination.

Guiding Principles Underlying the Reforms in Science Education

Any new syllabus should make provision:

(1) for courses complete in themselves for the first two years, which will give a suitable introduction to those not going further, and

(2) for a further course up to ordinary grade suitable for the pupil who will not take his study of science beyond this stage. Up to the Ordinary Grade it is felt that the emphasis should be on science for the ordinary citizen; yet at the same time the course must provide a good foundation to those who will eventually become scientists. These requirements are not easily reconciled, and to a certain extent some compromise has had to be effected.

Physics

The first step was to try to analyse the traditional physics teaching in Scotland. This led to the view that its characteristics were in the first place its didactic or academic approach, the idea that physics would be worth teaching as a discipline even if it had no practical application at all. This is perhaps linked with the fact that physics is still called natural philosophy in a number of Scottish universities. It is as a philosophy that the subject has often been taught even at school level. Today the emphasis ought to be on applications to everyday life rather than on

academic science. The second characteristic was its emphasis on the meticulous conduct of experiments for the determination of physical constants and the verification of physical laws. Thirdly, there was an emphasis on the learning of definitions and laws, it being assumed that this was a guarantee of understanding. And fourthly, the pupils were given no opportunity to discover things for themselves. They merely repeated what Archimedes, Boyle and Faraday had done before them.

Two things had to be done to reform this situation. It was obvious that if work in physics was to be brought nearer to the present day there would have to be a change of content. Traditional material would have to be removed and replaced by more modern material. At the same time it was also necessary to ensure that the teaching should encourage the critical and creative capacities of the pupils—in other words, the study of the subject should be made educative as well as merely informative. These two aspects cannot really be divorced from one another. It would indeed have been possible to change the content without changing the method but this would have achieved very little. It is the approach to the teaching that is of vital importance, but this approach can be very much facilitated by a syllabus which fosters it

It was therefore decided to base the new syllabus on the fundamental concepts running through physics rather than use the time-honoured method of compartmentalising the subject into mechanics, heat, light, sound, etc This gives a unity to the subject which in the traditional method is apt to be lost sight of Of course it was necessary to select the concept for study that would be most appropriate for the level of teaching and it was decided to deal with the physical basis of Newtonian mechanics, the kinetic picture of heat flow, waves of interconversion and conservation of energy, electromagnetism and atomic physics. Ideas of instrumentation would be developed throughout the course. It might be objected that this contains little that is new apart from dealing with the subject from the point of view of concepts rather than compartments; but the content in each topic includes much of modern significance and technological application. Thus in the section on energy it is expected that reference will be made to steam and internal combustion engines, turbines, jets, and rockets.

It has already been stated that a change of content above is not enough. It is vitally important that the method of teaching should be altered too. What is needed is the restoration to school science of the exploratory spirit, and an elimination of that detail which obscures the real physics, to work more from first principles rather than by applying formulae which have been learnt by heart and to cultivate a critical faculty among the pupils. This will involve a change also in practical work towards experiments which make more demand on the pupil's capacity to use his imagination and his creative powers rather than his ability to carry out a set of instructions which enable him to verify the value of a constant.

This does not mean that all experiments of a quantitative nature are banned There is a place for the determination of physical constants as accurately as the techniques of the school laboratory will allow, and this is well worth doing in certain cases.

There is some dissatisfaction on the part of teachers themselves about the nature of practical work carried out in school science laboratories. In most schools, the installation of and equipment of science laboratories is the most expensive part of the secondary school provision. Are we using these facilities to the best advantage? Most teachers would say no, for a variety of reasons which cannot be entered into here. This view has been endorsed by a recent investigation into the place of practical work in science in Great Britain carried out by Dr Kerr and his team at Liecester Institute of Education (1).

What is being tried with the new syllabuses is a transfer from didactic to exploratory and operational methods of presentation. The pupil thus gains more insight into the value of a phenomenon before he is asked to accept the laws which govern it

Chemistry

Chemistry has frequently been criticized as a school subject because it has so often consisted of the learning of a number of unrelated facts This had led some of our more able pupils to give up science in favour of arts, because of their intellectual disappointment with the standard science fare meted out to them.

In dealing with chemistry much the same problems had to be faced as with physics. An attempt was first made to lay down the fundamental principles on which the structure of chemistry is based and then to see how a syllabus could be constructed with those principles running through it. The concepts which are fundamental to chemistry are clearly energetics, atomic structure and bonding.

To a certain extent these are all advanced ideas which might be thought difficult for young pupils to comprehend, particularly by those brought up in traditional ways, and the problem was to introduce them into a course at an early age. To an extent, too, those concepts are not separate. Bonding, for instance, is dependent on energetic and it is, of course, necessary for an atomic model to satisfy the requirements imposed by energy considerations, in physics too it is possible to argue that one fundamental concept might embrace all the individual ones that we have mentioned earlier, and this might well be energy. However, to attempt such an all embracing synthesis is perhaps going too far and demands a philosophic outlook which comes only from great experience.

For the young pupil there is no doubt that energy is the most profitable starting point, but even so it would obviously not be wise to start with such a concept and base chemical study upon it. Chemistry is an experimental science; it is worked out at the bench. When we have our observations we can then attempt to link them up, and use the generalisation to predict what will happen in other cases and to bind together the facts we have discovered. So we let the pupils discover for themselves that chemical interaction is bound up with changes of energy of a system. Most frequently heat is given out in a chemical change, but not always. At first we are content with this and whenever chemical changes are encountered we see to it that energy considerations are brought to the fore-front Thus the burning of magnesium is not just a spectacular reaction in which a metal is changed to a white ash; there are

energy considerations too to be taken into account. In the study of combustion particularly they discover that the energy involved in chemical changes varies from one reaction to another and they are able to arrive at the idea of an activity series for the metals which is confirmed, at least in its essentials, when they study the action of metals on acids uncomplicated by side-reactions.

All this is purely qualitative, and we are not concerned with defining energy in the sort of way that a physicist would probably like us to do. We are satisfied to use the pupil's primitive ideas of energy, ideas which he may well have picked up at the primary school level, such as the fact that heat and energy are inter-convertible in the hot air engine In the science course either in physics or chemistry they soon become acquainted with the evidence for the fine division of matter and with the kinetic picture of heat, and it is not difficult to link this with the idea that collision between ultimate particles is required before combination will occur.

All the ideas at this stage are associated with the simple chemistry of air and water, and the solids of the earth, because, although the background of a scientific study of chemistry is being forged, it is necessary at the same time to give these pupils who will discontinue the study of science at the end of the second year, some knowledge of the chemistry of their surroundings. It is for this reason that some study of the earth has been included at this stage—a topic which has been woefully neglected in the early part of the course hitherto Teachers have usually been content to deal with air and water and leave it at that, and it has always seemed odd that we do not teach anything about the earth on which we walk, and from which we obtain so many of the products essential for civilization. It is true that the chemistry of the silicates is far from easy—but there is no need to give unessential detail at this stage—this indeed is one thing that must be assiduously avoided; but it is certainly desirable that an elementary, and even an introductory course should include some study of metals and their ores, and of building materials and so on.

Before the study of chemistry can be carried much further we need some model of the atom which will enable us to explain the types of bonding which occur in chemical compounds, and this is our next important fundamental principle. Here we are confronted by the difficulty which was encountered in physics, viz., that at this stage very little experimental evidence can be presented in favour of the model. There are two reasons, however, why it is felt desirable to introduce the pupils to such a model at this stage The first is that even if they go no further they ought to be acquainted with such terms as electron, proton, neutron, nucleus, isotope, and radioactivity, if they are to take an intelligent interest in what they read in the newspapers or see on T.V. The second is that, if they are going further, the model is extremely useful in giving a picture of bonding, and the demands of scientific integrity can be satisfied by pointing out that evidence will be provided later on for the essential validity of the model, and indeed the very fact that it does fit in with our chemical observations is itself some evidence of its truth

The next step is to attempt to classify substances simply according to their

electrical properties and show how the picture of ionic and covalent bonding will explain these properties. At this stage chemistry is a subject of 'blacks' and 'whites' and it is not wise to complicate the issue by pointing out that it is indeed a subject of 'greys'. In other words, only the extremes of polar or non-polar nature are considered; refinement comes later Once this idea of polarity is grasped many reactions become more comprehensible and this idea is used throughout the teaching from now on, so that the electronic theory of bonding becomes not simply a supplement to the course, as it frequently is in traditional syllabuses, but a powerful instrument for bringing order into the study of chemical action.

I have no time to indicate other points in the scheme save to mention that much of the traditional work has been omitted. For instance the work is based on an acceptance of the atomic nature of matter without going through all the work of Dalton; no time is, therefore, spent in verifying laws of constants and proportions —at the best unsatisfactory experiments from the quantitative angle at an elementary stage. If the atomic theory is accepted these laws must follow. Nor is the idea of equivalent introduced, but arithmetical and quantitative work is based on the mole or the gram formula weight. Traditional methods of finding atomic weights are ignored in favour of mass spectrography, the idea of which is not found difficult to impart when the pupils have followed the new physics scheme. The time thus saved is used to give some attention to organic chemistry of an everyday and non-academic type, such as that of fuels, foods, and polymers. These are all topics with which the ordinary educated citizen should have some acquaintance Further details of the scheme can be obtained by a study of the Department's Circular No. 512(5), which gives the syllabus, with notes on its teaching, and specimen examination papers.

This brings me to the point that the physics and chemistry syllabuses are so inter-related that they can be easily combined to give a satisfactory integrated course. In spite of the fact that I have in this talk dealt with the two syallabuses as if they were distinct it is not necessary to regard physics and chemistry as separate subjects

Biology

Some reforms have also been introduced into the teaching of biology. Traditionally in Scotland it has been the custom to teach botany and zoology as separate subjects, but it is now becoming widely recognised that at the early stages it is more valuable educationally to teach the essential features of living organisms, and the subject of biology has been introduced at both the Ordinary and Higher Grades and is becoming increasingly popular. A new biology scheme for the first two years has been published (6) which is based primarily on man and his place in relation to other living things. The theme running through the course is interdependence, which is brought out by means of field studies, the consideration of some simple aspects of social biology, and problems of conservation in nature. The course starts with human biology and there are here a number of links with other branches of science, particularly chemistry. Having learnt something of the working of the most familiar form of living thing, man himself, his relation to other living

organisms, both plant and animal is now considered. This leads to a more general study of the interdependence of plants and animals. Finally the way in which life is handed on, and man's influence on his own habitat are dealt with

This syllabus is in marked contrast with the rather sterile treatment associated with the more traditional work which has formerly been taught in the early stages in school and which comprised little more than a study of the bean seed, the life history of the butterfly and the frog, and the dissection of a flower.

It is hoped that the new syllabus will develop an interest in biology among the younger pupils and will encourage them to study the subject further in their later years at school.

A new approach, such as is envisaged in these syllabuses, requires a different technique of assessment which is in sympathy with the schemes, and new types of examination are being studied. While there is obviously a place in examinations for testing a pupil's knowledge of facts, this is not the main function of the test. It is desirable to examine much more than we have in the past the pupil's ability to use his knowledge and to apply it critically to the solution of problems which he has not met before. At the Ordinary Grade this is not very easy; any problems posed must be simple, moreover the examination is a period of nervous stress for all but the most confident, and thought processes are inhibited. On this account some teachers feel that it would be unfair to expect much more from pupils at this stage of development than the simple recall of what has been learnt. It certainly seems that, if questions demanding careful thought are to be set, the examination will have to be more leisurely, for the top speed working which is demanded of candidates in the present type of examination is inimical to original thought Experiments are taking place in a number of schools on these lines. The 'open-book' technique of examination is also being considered although this could obviously not be applied on a national scale because it would demand the use of the same textbook throughout the country. It would be possible, however, to supply a book of data to all schools which would be used in the examination and work on this has been set in train.

It is not, however, only in the final examination, or in the internal school examinations that change is required. The very technique of class questioning by the teacher in the course of the lesson requires to be reconsidered. The introduction of new syllabuses and methods is thus having a marked influence throughout the teaching of the subject.

The syllabuses that have been described have been offered to the schools as alternative to the more traditional ones. The reasons for this is that they have been produced at a time when there is a shortage of well qualified science teachers, and when the recent introduction of Ordinary Grade examinations had already made considerable demands on school staffs. In spite of this about half the schools in the country decided to adopt them last session, and something like two-thirds of the schools will be operating them in session 1963-64. This represents a very considerable achievement. Where schools have not adopted the new schemes, it is more often due to shortage of staff, or recent staff changes, or lack of suitable facilities.

A number of aids for teachers are being provided in order to help them to implement the new schemes as fully as possible. It is difficult to convey the spirit of the approach to physics and chemistry teaching which is envisaged through the printed word or even the spoken word; what is required are practical examples of the approach. The Department have, therefore, sponsored a film, which has been produced by Educational Films of Scotland, to try to show teachers what the new teaching involves. This film, entitled 'Physics for all', has been shown at many meetings of teachers and has received a great deal of praise.

In addition, several courses have been held at all the Colleges of Education in Scotland The interest of teachers in these courses has been so great that up to the present every one of them has been largely over-subscribed and it seems likely that courses of this nature will have to be provided for some little time yet At these courses, in which University teachers have also collaborated, a number of school teachers who have actually worked with syllabuses have described their experiences, and those accounts have been most valuable.

Shortly after the physics syllabus was issued, the Secretary of State for Scotland set up an Advisory Committee on Physics Teaching under the Chairmanship of Dr. S.C. Curran, the Director of the Royal College of Science and Technology, Glasgow. The Committee includes representatives of the universities, the Central Institutions, the Colleges of Education, teachers and the Department. It has done valuable work in reviewing apparatus, and in making recommendations about the layout and equipment of school laboratories, and about the recruitment of teachers.

The Department have issued memoranda about the teaching of various sections of the physics and chemistry syllabuses, and these have been sent to all schools free of charge. We have been greatly helped by the Nuffield Scottish Physics Team, members of which wrote some of the physics memoranda.

The Scottish Branch of the Association for Science Education has also taken a leading part in promoting the acceptance of the new schemes by devoting a good deal of its annual meetings in the last two years to a consideration of the syllabuses and a display of suitable experiments. It has also arranged area meetings in different parts of the country, and members of the Association have helped in the production of the memoranda dealing with the chemistry syllabus.

The Education Authorities have naturally a large part to play in ensuring the success of the whole operation. In the majority of cases they have acted generously in the matter of provision of new equipment required for the teaching of the syllabuses, and some Authorities have responded well to the Department's suggestion that laboratory technicians and assistants should be appointed in order to ease the burden which the changed emphasis on practical work would place on teachers.

Such is the interest of the teachers themselves in the new syllabuses that groups have been formed up and do down the country to discuss the teaching of various sections, and to work out experiments to illustrate the courses, and in some areas associations of science teachers, already existing, have been infused with new life. It is indeed not too much to say that we

are living through a period of a renaissance of science teaching. Such a period is a challenging one and an uncomfortable one; well established methods have to be thrown over in favour of new, and less well-tried ones. The fact that the vast majority of Scottish science teachers are prepared to face this challenge says a great deal for their vision, and their adaptability.

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Science Teaching in Ghanaian Schools

Background

Following independence in 1956, it became a matter of great importance that some action had to be taken quickly to improve upon the low percentage of illiteracy and to provide the future citizen of Ghana with the type of education which would make him a full citizen of the larger world and also to set the stage for producing the large number of manpower required for industry and scientific agriculture in a rapidly developing country. The type of education for achieving this aim was seen to consist in a general training which was science oriented.

It was recognised that science teaching in Ghana had hitherto been too theoretical and had been based on the learning of facts and definitions instead of on sound experimental observations; that the Cambridge School Certificate examination had played too dominant a role in science teaching and this has resulted in the rigid following of a syllabus leaving little scope for the imagination of the pupil. Also the teaching of science had been based on imported European syllabuses which required the study of materials and the imparting of ideas completely divorced from the experiences of the Ghanaian child. Most of the experiments that were carried out in school laboratories were for the purpose of acquiring manipulative skills rather than in a spirit of scientific enquiry, a limited number of the same experiments being repeated over and over again throughout the School Certificate course in preparation for the final practical examination. The old traditional explanation of natural phenomena still persists in many African countries in spite of long contact with Western ideas. This is linked up with illiteracy.

Present Attitude Towards Education in Ghana

The awareness of the need for education in general and science education in particular is spontaneous and very great indeed. There is almost 100 per cent realization by Ghanaian leaders and children that science education is absolutely necessary for expressing a person's full personality in the world around him.

Structure of the Educational System

The stages of pre-university education consist of a Primary-Middle Stage of 10 years now in the process of being shortened to 8 years and eventually to 6 years, followed by a 5-year Secondary stage for the School Certificate course and then a 2-year Sixth Form Course. This year, 1963, the 5-year School Certificate course has been shortened to a 4-year course. The present age of entry to the Primary school is 6 years, and selection to the Secondary school takes place after 8 or 9 years of the elementary school so that the majority of secondary school entrants are 14 years old. By a recent Government ruling, children at the top of the elementary school may also qualify for selection to the Secondary school through the selective examination, so that a child who passes through the elementary school has three chances of qualifying for selection

Paper presented at the Commonwealth Conference on the Teaching of Science in Schools, held in Peradeniya, Ceylon in December, 1963.

to the secondary school.

The Primary-Middle (elementary) stage is compulsory and free and textbooks and writing materials are supplied free of cost.

There is free supply of textbooks, on loan, to all children in the secondary school. Also half of the secondary school population are on government scholarships or bursaries.

Government pays full fees to the schools for all students who qualify for admission to the 2-year Sixth Form courses and in addition pays for them a certain percentage of the cost of textbooks.

Action Being Taken for Science Education

THE ELEMENTARY SCHOOL: The teaching of science has not yet come fully to all elementary schools but science is now compulsory in all Teacher Training Colleges where future teachers for the elementary schools are trained.

Also since the declaration of fee-free compulsory elementary education in Ghana, government has invited United Kingdom science experts to Ghana at various times to help in the plan for introducing science in the elementary schools.

Experimental teaching of elementary school science is now being carried out in some selected elementary schools and the chief agency in this programme is the University of Ghana Institute of Education. This programme is based on the curriculum developing from the United States Elementary Science Study.

This year, 1963, an Institute of Science Education has been opened in our Kwame Nkrumah University of Science and Technology for the purpose of working on elementary school science immediately and later, to extend its researches upwards to the secondary school.

Science centres are developing in the cities and large towns where children from the higher classes of elementary schools go in rotation for a few hours of science each week.

THE SECONDARY SCHOOL: Within the past ten years, the number of secondary schools in Ghana has increased from 26 to 85. Each of the new secondary schools is provided with three science laboratories in a large science building and Government gives an initial financial grant of large size for the purchase of science apparatus. Also annual recurrent grants are given to all schools, new and old, for replacements and addition of apparatus. Large sums of money have been made available by Government for providing extensions to the science laboratories of the old secondary schools to meet the demands of the expanding science programme.

Textbooks and the Medium of Instruction

Science textbooks used in African secondary schools are European in outlook and unrelated to the experiences and surroundings of the children. Some research is at present going on in the universities for providing more suitable texts on local material. So for the present, the child has difficulty with his textbook and unintelligible memorization may be done unless the teacher is able to modify the text and replace foreign examples with local ones.

Coupled with this is the fact that the medium of instruction throughout the school is English which the child will not have mastered by the time he is ready for the secondary school.

The Government of Ghana is taking steps to intensify the teaching of English in the elementary schools, and a recent Government directive requires that the medium of instruction right from class I of the elementary school should be English. Prior to 1960, English as a medium of instruction in the elementary school started only in class III.

The Ghana Association of Science Teachers (GAST)

The Ghana Association of Science Teachers is doing a great job to influence science education in Ghana It is affiliated to the Association for Science Education in Britain (A.S E.) and its primary function is the advancement of science education It does not concern itself in anyway with matters affecting conditions of service of teachers.

Secretariat for Science and Technology

A recent Committee appointed by Government to look into the matter of pre-university education has just reported In the section of the report on science education, the Committee point out the defects in the existing methods of science education and then make appropriate recommendations. The most significant of the recommendations is that there should be established under the President's office a Secretariat of Science and Technology to set up a centre for the supply, production and distribution of teaching aids and laboratory equipment and to participate in the work of science curriculum development.

Nigerian Experience

Background

Nigeria is a federation of four regions each region being responsible for the education of her populace. The pattern of education in the federation is as follows:

- 6–8 years of primary education
- 5 years of secondary education
- 2 years of sixth form work

There is universal free primary education in some of the regions. Children enter the secondary schools at the age of 11, 12 or 13 by entracnce examinations. Less than 10 per cent of the children of this age group gain the entry

Science Teaching

Science is not taught in all the Nigerian secondary schools The curriculum followed is almost entirely determined by the requirements of West African School Certificate. The examining body—the West African Examination Council—took over its syllabus from the Cambridge Overseas School Certificate examination. This situation is a result of practice.

There are two aspects of this curriculum, the general science and the separate sciences The general science is the simple form and is usually taken by schools which are beginning science or which have very poor laboratories. The well established schools, however, offer physics, chemistry and biology.

One weakness in our school science is that the syllabus and the textbooks are not indigenous. For instance, in biology the animals and plants described in the textbooks are unfamiliar to the pupils They therefore resort to memorization. This situation is gradually being arrested.

A survey of the situation in schools showed that the factors which govern the study of science affect the boys' schools and the girls' schools equally In many areas, particularly in the rural areas, there are more boys' schools than girls', while in the urban areas the number of girls' schools compares favourably with those of boys' schools. Girls' schools tend to keep longer at general science and often offer biology as the only science subject in their examinations. They also have more students dropping science altogether than boys' schools.

The aim of science education in Nigeria is almost completely utilitarian; in fact, inadevertently it is geared to providing personnel for the civil service, commercial and industrial concerns. There is a great demand for science teaching in our secondary schools Parents do not want to send their children to schools where science is not taught, or withdraw their children from schools where science is not properly taught A candidate with a good knowledge of science stands a better chance of winning a scholarship to a university. In one of the regions the teaching of science is now compulsory in all secondary grammar schools and no new school is allowed to operate unless it teaches science.

After the five-year school certificate

Paper presented at the Commonwealth Conference on the Teaching of Science in Schools, held in Peradeniya, Ceylon in December, 1963.

course, there is a further two years of sixth form work in some of the schools. The syllabus is completely determined by Cambridge University requirements for Overseas Higher School Certificate examinations.

Apart from the normal five-year secondary school course there is a three-year modern school course, mainly in Western Nigeria and Lagos. These schools absorb a number of students who do not enter the grammar schools. The science taught here is of the general science standard.

Primary School Science

Science in the primary school has been taught as hygiene, nature study, and rural science. The principal aim of hygiene was to inculcate in the children the habit of cleanliness and hygienic living. Nature study was, in fact, elementary biology and simply physical science. Rural science was intended to teach agriculture. The primary school science had something which the secondary school science lacked. It was down to earth, the pupils used the everyday things around them; their only laboratory was the field, and it was an effective one.

There is at present a move to introduce in a big way the study of science in the primary school, at a standard at which it is done in the lower forms of the secondary schools. This has started as a pilot scheme in Eastern Nigeria. In this region 80 primary schools started science in January 1963, and if funds are available 400 more schools will join in the next five years. The problems involved in this scheme are the lack of qualified teachers, textbooks and equipment. The scheme rests much in the hands of those teachers who did science in the grammar schools before going to the teacher training colleges. The government has also been organising refresher courses and evening classes for more teachers, and plans to introduce science in all the teacher training colleges.

To popularise science, the government plans to use institutions as places where science as a way of life can be taught to the masses, by organising regular science fairs and occasional lectures.

Problems

(a) Insufficient Laboratories and Inadequate Science Equipment: Because of lack of funds it has not been possible to meet the ever increasing demand for secondary school education. On the average, about 50 new secondary schools are built every year. To equip all the existing secondary schools and all the new ones with up-to-date material for science teaching the cost will run into millions of pounds.

(b) Shortage of Science Staff: Despite the large number of science teachers from outside Nigeria, only about 52 per cent of the science teachers are graduates. The introduction of science in the primary schools has also increased the demand for science teachers of a status lower than graduates. This is a difficult problem, since most of our teacher training colleges do not offer science, and the teachers who go in them for training do not receive any science training in schools.

(c) Curriculum, Syllabuses and Text-books: In the secondary schools the curriculum and syllabuses are geared to satisfy the examinations. The sixth form syllabuses are entirely dependent upon Cambridge and London Universities' requirements, which are foreign. It has already been

mentioned before that our textbooks are foreign. (a) Equipment: To help equip the new schools the governments give special grants to be used solely to build and equip science laboratories. These grants in most cases are insufficient to build and equip the laboratories. One Ministry has set up a committee to explore the possibility of manufacturing low cost science kits for the secondary schools. (b) Syllabus Because of pressure from teachers and science organisations, the West African Examination Council is modifying its syllabus to suit local needs.

Young folks corner

SCIENTISTS YOU SHOULD KNOW

GALILEO GALILEI—400th Birth Anniversary

Galileo questioned freely the statements of great authorities like Aristotle and Aquinas. His determined efforts for foregoing a break with tradition have earned for him an honourned place in the history of science.

IT was Galileo Galilei—and that was his full name—who, more than any other of his time, heralded the era of experi-

mental science, opened new vistas of astronomy, and gave new dimensions to physics. This year marks the 400th birth anniversary of this great genius; it was on February 15, 1564 that Galileo was born in Pisa in Italy. He lived for 78 years and his eventful life saw the height of scholastic fame as also his tragic end in isolation.

From his early age Galileo showed signs of versatility which was to become one of the most conspicuous traits of his personality. He learnt as diverse languages as Greek and Latin, and showed aptitude for as divergent fields as logic and literature on the one hand and paintings and music on the other.

The father had desired his son to become a doctor and had actually sent him to Pisa for medical education. Galileo, however, found mathematics and scientific experiments more fascinating. His first major break-through in the realm of science came in 1582 when his eyes caught the swinging church lamp hanging from the high ceiling of the hall. He

Reprinted from *Science Reporter* 1 (2) : 1964, with the kind permission of the author and the editor

observed the oscillation and figured out that the swinging periods were the same even though the width of the swinging gradually became shorter and shorter The time recorder in this great experiment was his own pulse. By nature an experimentalist, he came back home and made a simple pendulum by suspending a bob by a string and firmly declared that the periods of oscillation of a pendulum depended on the length of the string. Thus started the mind that was to probe several other phenomena later.

Galileo neglected the study of medicine to immerse himself in the great joy of mathematics and scientific experimentation. At the age of 26, Galileo was appointed professor of mathematics at Pisa It was a poorly paid job, but then money did not matter much to him. Here, he questioned the Aristotelian principle that the heavier body must fall faster than the lighter body, and finally proved that the principle was wrong. Inevitably this landed Galileo in trouble. Aristotle's personality was dominating, and his philosophy had remained sacrosanct for nearly eighteen hundred years. Galileo's scientific evaluation of Aristotle's teachings gave his jealous colleagues a handle with the result that in the course of two years he had to leave Pisa. In 1592 he became professor of mathematics at the Venetian University of Padua, where he stayed for 18 years. His life there was comparatively free from trouble.

Galileo's reputation as a teacher spread far and wide in Europe. People came from all parts of the Continent to learn mathematics and science from him. In 1602 Galileo invented the air thermometer and subsequently, military and geometric compasses.

Astronomical Observations

Galileo made his first telescope in June 1609 though he was not the original inventor. On January 7, 1610 he turned his telescope to the planet Jupiter. He found that it was like a magnified disc, and also discovered three of the largest satellites which appeared as shining specks of light Observing them over a few nights, Galileo determined the periods of rotation of the satellites round the planet. His studies clearly established that Jupiter was a planet like the Earth, with its circulating moons. Then he noticed the phases of Venus and concluded that the planet is non-luminous but shines in the sun's light. Galileo then turned his telescope on to the Moon, and found that markings on it were actually shadows cast by the lunar mountains in the presence of sun light. One after another, Galileo unveiled the mysteries of the sky. The sun spots could be seen clearly, and his telescope showed for the first time that the Milky Way was nothing but myriads of remote stars that sparkled in the telescopic view By now he had realized the truth of the theory of Copernicus (1473-1543) that the earth moves round the stationary sun

The Inquisition

This was contrary to the then existing belief that the earth the home of man was motionless and the heavenly bodies including the sun moved round it. Trouble followed soon. The Pope and the priesthood were averse to giving up their stranglehold on the society and the astronomical mysteries were among the main handy tools to perpetuate their hold and power. In 1615 Galileo had to appear as the accused before the Papal Supremacy and was found guilty of

supporting the Copernican theory and propagating it.

Thoroughly humiliated and dejected, and with the memory of Geordano Bruno (1548-1600) who was burnt alive for the heresy fifteen years earlier, Galileo had to kneel down and recant.

After his release, Galileo decided to tread on safe grounds. Eight years later in 1623, Barberini, who was a personal friend of Galileo and had a great regard for him, became Pope Urban VIII. With this happy turn of events, Galileo took up astronomical studies once again.

The goodwill of the Pope encouraged Galileo to write his famous book: 'Dialogues on the Two Chief Systems of the World, i.e. the Ptolemaic and the Copernican' which was published in 1632, with Papal approval.

But his enemies were only waiting for an opportunity to strike him down. They found in the Dialogue a 'powerful plea for Copernicanism' in spirit. They cunningly put it to the Pope that the stupid character, the upholder of Aristotelian doctrine in the Dialogue, was none other than Pope himself and that Galileo had cleverly discredited the Pope and the Church. This vicious trick worked

But, 'perhaps out of respect for his age and infirmities' or perhaps because the Pope remembered with a bit of shame his former friendship, Galileo was not imprisoned and tortured, but was detained in Rome under suspended sentence. Ultimately, he was allowed to return home at Arcetri, although still a prisoner.

During the last ten years of his life Galileo worked at home. In 1636 he published his 'Discourses Concerning two New Sciences', in which he discussed motion and cohesion (or resistance) of the medium His argument led to the establishment of correct formulae for motions under uniform acceleration and to the conclusion that the path of a projectile is a parabola provided that the medium did not offer any resistance or the projectile moved slowly enough, and provided the path was small compared to the size of the Earth. Galileo also concluded that if resistance were removed, a body projected along a horizontal plane would continue to move for ever. This indeed forms a part of the laws of motion which Newton enunciated about half a century later.

Galileo's eyesight began to fail at the age of 70 and by 1638 when he was 74, he became totally blind. He died on January 8, 1642 at the age of 78

Father of Modern Physics

Galileo's versatility comprehensively influenced various branches of the Physical Science to which he applied mathematical principles successfully. His particle dynamics, fluid mechanics, and astronomy brought about a complete revolution in the scientific concepts of the physical world. The great departure from his predecessors was his love and competence for instrumentation and experimental verification of the laws and theories which he propounded. Galileo is widely, and quite correctly, regarded as the father of modern physics. To be sure, physics had grandfathers and still more remote ancestors, but none of them bequeathed to physics, particularly to experimental physics, so much as Galileo.

K. RAY

Test Your Knowledge

What advantage do many birds gain by flying in V-formation?

As a bird flaps its wings it disturbs the air and leaves whirling eddies behind Some gregarious species take advantage of the upward sections of these whirls and each bird in the V-formation stations itself at the correct place so that the inner wing obtains support from the wake of the bird immediately ahead. Thus every bird in the flock except the leader saves energy by using the V-formation type of flight.

What are meteorites and meteors?

Meteorities are the parts of the solar system that eventually reach the surface of the earth. They may be regarded as metallic and stony rocks of igneous type resulting from the break-up of a lost planet very much like our own. As they streak through the protecting atmosphere that envelopes the earth they are heated by friction to incandescence, leaving behind them a cloud of gas at a temperature of several thousand degrees—this is the visible part or the meteor. Meteors or 'shooting stars' differ greatly in brightness and assume various aspects. Glowing streaks or train are typical—appearing as a fine line, then brightening, fading again, and bursting in a final flash. Some make spinning flares, others split into several parts, a few trains consist of dust and smoke illuminated by sunlight. The larger the meteorite and the faster its speed, the brighter will be the meteor. Only the largest bodies survive the trip and land on the earth.

How does a Geiger counter work?

The most general means of detecting and measuring radioactivity is through the use of the Geiger counter. Beginning as a bulky laboratory instrument, it has now developed into a portable, light-weight, and relatively inexpensive piece of equipment that is remarkably versatile.

Gamma rays and some beta rays penetrate the walls of the Geiger-Mueller tube, where they collide with a molecule of an inert gas inside it and yield charged particles. Some of these are attracted toward a metal wire running the length of the tube and produce an electrical impulse, which is amplified This is then recorded on a meter or else it causes an audible click in a set of earphones or a flash in a neon light. In the portable instruments, batteries supply the power which does these things as well as creating a high voltage between the wall of the tube and the centre wire.

How large can crabs grow?

The largest crab is a spider crab of the North Pacific which lives in comparatively deep water from the coast of Japan to Alaska. When stretched out it may measure ten feet from the tip of one claw to the tip of the other, the body itself being about twelve by eighteen inches across. Large rock crabs species of *Cancer*, found along the northern pacific coast of America and also in northern European waters may grow to be fifteen inches wide, with massive, chunky claws in proportion.

What is the cause of earthquakes?

During the steady shrinkage of the earth's crust gigantic forces of compression develop laterally, that is, parallel to the surface. Cracks called faults develop and persist for hundreds or thousands of years. As pressure continues, a slip occurs occasionally, readjusting the position of material on the two sides of the fault. Such a slip may be very slight—a few feet or so—yet cause enormous trains of vibrations to radiate out through the ground from the point of slip, called the epicenter. Many quakes originate far within the earth, causing no movement on the surface, although the shocks are rapidly transmitted to it. Quakes sometimes accompany severe volcanic eruptions.

Why do stars twinkle while the moon does not?

The stars are so far away that all we can see of even the nearest star—apart from the Sun—is a point of light which has only one dimension—length. The atmosphere of the Earth with its air currents, varying temperatures and turbulences, affects that point of light, sometimes dimming it, sometimes intensifying it, sometimes quenching it altogether. The result is a twinkle. In the cases of the Moon and the planets, we see not one single point of light but a perceptible disk made up of an infinite number of points of light. When any one of these infinite points of light is affected by the atmosphere, others are not, and we see therefore, a steady image. Even the planets, however, when they are seen near the horizon through the densest portion of the atmosphere, will twinkle.

What keeps the satellite in its orbit?

A combination of velocity and gravitational pull keeps the satellite in its orbit. Let us take the Moon as an example. The Moon moves around the Earth at a velocity of 3,350 feet per second. Each second, gravitation pulls it towards the Earth about 1.19 of an inch. It might be said that the Moon falls around the Earth, but it will not fall to the Earth unless its forward motion should diminish.

An artificial satellite at a height of 300 miles, will be pulled toward the Earth about 14 feet every second, but it will also move forward about the Earth about 5 miles in that same time. The combination of forward motion and fall will balance each other and keep the satellite in its orbit until its velocity is diminished.

Science notes

SCALE WEIGHS SUBSTANCES WHICH WEIGH 'NEXT-TO-NOTHING'

A MEASURING instrument so sensitive that it can detect the weight difference if two words are added to a 30-volume encyclopedia has been developed for commercial use in the United States.

Known as the 'Model 701 quartz-crystal microbalance', the device can even measure the weight of the ink represented by two words. Developed by the Westinghouse Research Laboratories, Pittsburgh, Pennsylvania, the device is so simple to operate that these sensitive measurements can be made routinely by unskilled personnel

The machine, which weighs only 8 5 lb. (3 8 kg.), is expected to find many uses in various space-age industries such as molecular electronics. This involves manufacture of complicated apparatus of such minute sizes that components are invisible to the unaided eye.

For example, an entire radio amplifier can be made on a wafer the size of a small coin.

In related experiments, scientists at the Westinghouse Research Laboratories are using ultra-high vacuum chambers to produce films only 10 atoms thick. It would take 250,000 of these films to equal the thickness of a newspaper page. These films can be weighed with the new scale.

The microbalance determines weight by measuring changes in mass deposited on a crystal surface. The mechanism determines the weight of that mass by measuring changes in resonant frequency of the crystal.

NEW ANTENNA MAY HEAR ASTRONAUTS' SMALL RADIO ON THE MOON

Scientists in Concord, Massachusetts, are making plans for a radar-radio telescope antenna capable of receiving signals from a small radio operated by Project Apollo astronauts on the moon.

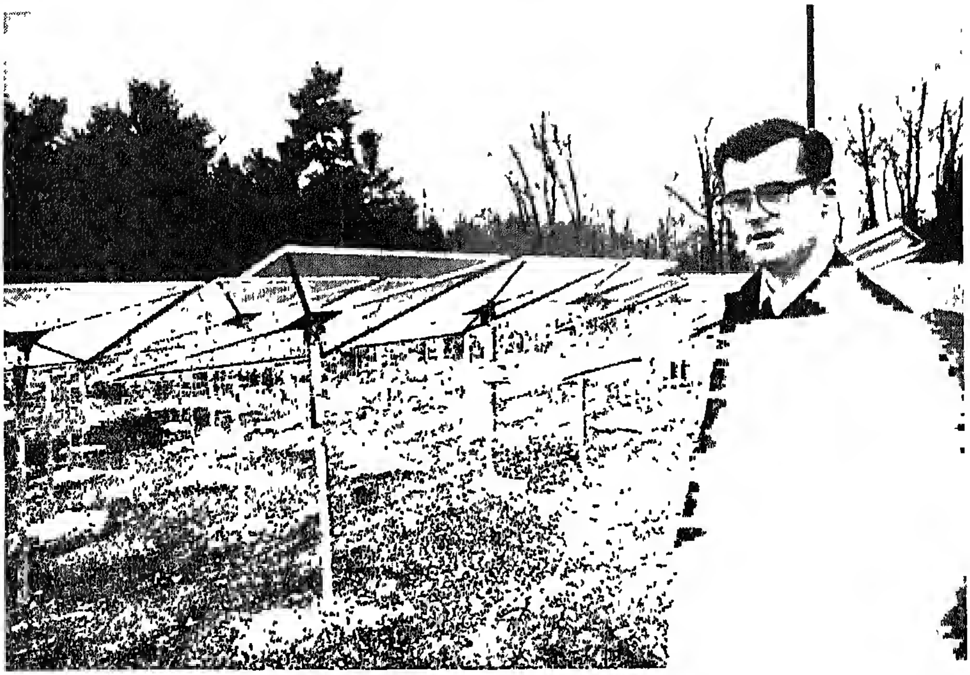
The U.S. Air Force also is conducting research with smaller antennae for tracking satellites and other spacecraft from its nearby Strawberry Hill field station.

Dr. Allan C. Schell, a civilian scientist, heads the antenna project. He is being assisted by Dr L. J. Chu of the Massachusetts Institute of Technology and other specialists.

Their latest device is a radio-radar antenna composed of 220 square plates of aluminum fastened to vertical pipes.

The plates are arranged in the form of an ellipse measruing about 70 by 120 feet (21 by 36 metres). Unlike conventional antennae which move as a single unit, each five-foot (1.5-metre) plate can be adjusted individually in any desired direction from vertical to 45 degrees.

Dr. Schell says, extensive experiments with his antenna so far have shown good results at the radio frequency of 1,400 megacycles.



A new arrangement of antenna plates at Concord, Massachusetts.

He believes his radical design will be extremely accurate, yet inexpensive compared to the large conventional 'dishes' now in use.

The largest movable dish is a 300-ft (90-metre) diameter radio telescope at the National Radio Observatory in West Virginia. The largest fixed dish antenna in the world is being completed at Arecibo, Puerto Rico, by the Air Force and Cornell University of New York. It is a 1,000-ft (300-metre) bowl set in the ground and topped by a movable focusing device.

However, even these two antennae are not expected to be sufficiently accurate to track spacecraft at the enormous distances involved in exploring the solar system.

Because it is impractical to build even larger dishes or rod-shaped antennae, new methods must be found to allow for deeper electronic probes into space.

Dr. Schell believes the new 'multi-plate' system may be the answer.

He and his colleagues have designed a giant version of their experimental model which, when linked with sensitive amplifiers, should be able to hear signals generated by a hand-held radio on the moon, some 240,000 miles (348,000 kilometres) distance.

If this antenna should prove successful, U.S. astronauts would not have to carry along heavy, bulky transmitting equipment in their Apollo spacecraft which scientists hope will land on the lunar surface by 1970. Instead they could take along portable communications equipment which might be part of their pressure suits.

MAGNESIUM FOUND IMPORTANT IN HUMAN METABOLISM

Recent findings of the importance of magnesium in human metabolism have prompted a study by United States Department of Agriculture nutrition specialists

Their studies indicate that the chief biological role of magnesium is as an activator of many important enzymes. These enzymes are involved in muscular activity, nerve conduction, glucose use and the synthesis of proteins, fats, carbohydrates and nucleic acid. Magnesium metabolism is found closely related to that of potassium, calcium and phosphorus, but its relation to endocrine functions was not established.

Human requirements of magnesium seem related to protein intake, since as protein consumption increases magnesium need is also increased. Using this relationship as a guide, researchers have developed estimates of daily magnesium requirement (based on normal U.S. protein consumption) as follows: Children up to ten yars, 150 mg; pre-adolescents, 250-300 mg; young women, 300 mg; young men, 400 mg.

The researchers point out that adequate magnesium intake is not a problem for normal persons on an adequate diet, but maintaining magnesium equilibrium might be a problem when amounts of several related nutrients are limited.

LONG LIFE ELECTRIC BATTERY

A long-life electric battery which draws power inexpensively from harmless bacteria has been developed in the United States. Known as a 'Biological Fuel Cell', it has a theoretical life expectancy of more than 50 years during which it produces electricity continuously. The cell harnesses the energy of thousands of bacteria inside it and makes this energy available in the form of electricity.

A pilot model of the cell—which produces enough energy to power a transistor radio, a small light bulb or a miniature motor—has been designed for educational and demonstration purposes in schools or for use by students and hobbyists in home experiments. This model, developed by the Electron Molecule Research Company of San Antonio, Texas, is for sale at $ 16.95 by the Bulk Distributing Corporation of Tacoma, Washington.

The developers are now designing a compact, easily portable, but more powerful model for use in the less developed nations which need inexpensive, long-lasting power sources. Still other models are planned as private sources of electricity for homes, airports, railroad signals, electrified fences, stand-by supply for business and industry, at isolated locations such as buoys, or for use on long space voyages.

The main components of the model are 12 plastic containers, about the size of medicine pill bottles or small ink bottles, filled with brown powdered rice husks. Shipped with the unit from the manufacturer comes a bag full of bacteria—which are, microscopic organisms similar to yeast or bread mould. These bacteria are then mixed with water and the rice husks. The husks decompose as the bacteria 'feed' on them. Electric energy resulting from this process is picked up by a strip of copper which serves as a positive connection, or 'anode', for the electric current and a strip of aluminium which serves as a negative connection or

'cathode.' These metal connections protrude from each plastic container and are joined by wire to the radio, light bulb or motor to be supplied with electricity.

Even the developers are puzzled as to precisely how the new process works. Scientists believe electric energy is produced either by the decomposition of organic matter or through a by-product emanating from the bacterial action on organic matter.

The model units have no switch for turning the power on or off because electricity would keep on being produced even if a switch were in an off position. Besides, continuous operation has no effect on the cells' life or efficiency. The unit is self-contained, needing no outside connections and emitting no noticeable odours, but each cell container requires an opening for air intake

Once assembled, the unit needs no attention except occasional refilling with rice husks and water for the thousands of industrious 'worker' bacteria which reproduce themselves indefinitely.

NEW ANTI-MATTER PARTICLE DISCOVERED BY U S. SCIENTISTS

U.S. Scientists have torn another new particle out of the atomic nucleus

It is an elusive bit of anti-matter that has no electrical charge and a lifetime of about one ten-billionth of a second. It is called the Anti-XI-Zero.

The particle is so rare that scientists could not discover it by chance. Because it was predicted by theory, they were able to arrange an elaborate series of experiments with the world's most powerful 'atom smasher' to ferret it out.

The discovery was made by a team of Yale University and Brookhaven (New York) National Laboratory physicists. They reported their work in the August 15 issue of 'Physical Review Letters.'

Anti-matter is composed of the counterparts of ordinary matter, for example, anti-protons instead of protons A fundamental theory of physics says that for every known elementary particle there must be an anti-particle

For the experiment, scientists accelerated a beam of anti-proton particles around the huge oval track of the Brookhaven Laboratory's synchrotron machine and sidetracked them into a bubble chamber. Here they collided with ordinary protons, leaving a visible trail. The physicists had to take 300,000 photographs of these collisions to 'observe' the production of three Anti-XI-Zeros.

Because the new particle has no electrical charge it does not leave a track in the chamber, nor do the particles it breaks down to. However, the subsequent decay does leave tracks. The presence of the Anti-XI-Zero was deduced from this chain of events.

The new particle is one of some 35 subatomic bits physicists have discovered with powerful accelerator machines since World War II. Most of the work has been done in the United States but with the help of visiting European scientists.

The scientists noted that any new particles found in the future would require the start of entire new families of these fundamental building blocks of matter. Several such new families have been postulated.

By Courtesy of U.S.I.S. New Delhi.

THE MOON AND THE WEATHER

The age-old belief that the moon has an effect on the weather—generally discredited by meteorologists—has now received firm scientific support as a result of recent work by the Division of Radiophysics of Australia's Commonwealth Scientific and Industrial Research Organisation. An analysis of weather records has revealed that heavy rain is more likely during the first and third weeks of the lunar month—particularly three to five days after both new and full moon.

Observations carried out by the Division some 10 years ago have revealed that peaks in average rainfall were often preceded by a shower of meteors or shooting stars about 30 days earlier This had led to the hypothesis that a significant proportion of rainfall is triggered off by dust particles resulting from the impact of meteors on the lower atmosphere. It was considered that the meteoric dust particles acted as nuclei around which cloud particles could freeze and ultimately produce ice crystals large enough to fall out of the clouds and molt, appearing on earth as rain droplets.

In order to explain the effect of the moon on rainfall, scientists of the Division of Radiophysics have put forward the theory that the moon might somehow deflect meteoric dust away from the atmosphere when it is in certain phases with respect to the earth and the sun, so that fewer freezing nuclei are provided to trigger off rainfall.

The Division's scientists have obtained support for this theory from their observation that the number of freezing nuclei in the atmosphere also varies with the phases of the moon.

Further support was provided when an examination of radar observations of meteors for both the northern and southern hemispheres showed that the hourly meteor rate also varied in the same way as rainfall, being greatest during the first and third weeks of the lunar month.

By Courtesy of Australian High Commission,
New Delhi

New trends in science education

Summer Institute Programmes

AS reported earlier, the National Council of Educational Research & Training, the University Grants Commission and the United States Agency for International Development propose to hold jointly 16 Summer Institutes for Secondary School Science Teachers during this summer from June 8 to July 17. Four of these will be in Biology; four in Chemistry; four in Physics and four in Mathematics. Like the Institutes held last summer, these Institutes are primarily designed to enable the faculty members and participants to try out the new programmes of science teaching in their respective areas and see what new features may be incorporated in the science classes of the secondary schools and the Pre-university classes in the colleges. They are to be taught, as far as possible, according to the approaches developed in these new programmes, i e. an investigatory laboratory experience will be stressed. The participants will be using the text and laboratory equipment developed in these courses. Each Institute will have on its faculty three professors or readers from the Universities where the Institute is to be held plus two American specialists (i) a University Professor, who has had connection with conducting of Summer Institutes or with the writing of materials in America and (ii) a secondary school science teacher, who had had experience of teaching these programmes in the United States, and a participant from one last year's institutes as a laboratory assistant. There will be one Institute in each subject and in each region of the country. The Institutes will be located as shown in the following table.

An orientation seminar for the Directors and faculty members of these Summer Institutes was held for a week from February 10 to 14, 1964. The seminar was conducted by the American Scientists, who were brought to Delhi for this purpose and it was held at the University Grants Commission Building with Dr. D.S.Kothari as Chairman. The American scientists, who were invited were: Dr. William R. Morrell, Programme Director, Summer Institutes, National Science Foundation; Dr. Arnold B. Grobman, Director, Biological Sciences Curriculum Study, Dr. Alfred Romer, Professor and Head of Physics Department, Princeton; and Dr. Howard Fehr, Professor and Head of Mathematics Department, Teachers College, Columbia University. At this seminar, the manner in which the Institutes are to be conducted was discussed at length and each subject group spent considerable time studying the new approaches and the new content to be included in the Institutes for secondary school science teachers. In these discussion sessions a

SUMMER INSTITUTES TO BE HELD DURING 1964 FROM 8TH JUNE TO 15TH JULY 1964

Subject/Region		University	Place	Name of the Director
Biology				
1.	Northern	Delhi	Delhi	Dr. B.M. Johri, Professor of Botany, Delhi University
2.	Western	Institute of Science Bombay	Bombay	Dr. D.V. Bal, Director, Institute of Science
3.	Southern	Madras	Madurai	Dr S. Krishnaswamy, Professor of Zoology, Madras University Centre Madurai
4.	Eastern	Utkal	Bhubaneswar	Dr. B. Samantrai, Principal, Ravenshaw College, Cuttack
Chemistry				
5.	Northern	Rajasthan	Jaipur	Dr. R.C. Mehrotra, Head of Chemistry Department, Rajasthan University
6.	Western	Poona	Poona	Dr. V.K. Phansalkar, Acting Head of Chemistry Department
7.	Southern	Osmania	Hyderabad	Dr. Subba Rao, Principal, College of Science
8.	Eastern	Burdwan	Burdwan	Dr. S.K. Siddhanta
Physics				
9.	Northern	Banaras	Varanasi	Dr. A.R. Verma, Professor of Physics and Head of Department
10.	Western	Gujarat	Ahmedabad	Dr. Y.G. Naik, Professor of Physics and Head of Department
11.	Southern	Karnatak	Dharwar	Dr. N.R. Tawade, Professor of Physics and Head of Department
12.	Eastern	Gauhati	Shillong	Dr. P.C Mahanta, Professor of Physics and Head of Department
Mathematics				
13.	Northern	Kurukshetra	Simla	Dr. S.D. Chopra, Head, Mathematics Department
14.	Western	Baroda	Mount Abu	Dr. (Mrs.) Indira Bhanot
15.	Southern	Mysore	Mysore	Dr K. Venkatachalaiengar
16.	Eastern	North Bengal	Darjeeling	Dr. S.R Das Gupta, Head of the Department of Mathematics, North Bengal University

sheletal programme, was worked out for the institutes.

As was the case in 1963, the Institutes are being jointly sponsored and financed by the University Grants Commission, the National Council of Educational Research & Training and the Teachers College, Columbia University Education Team of U.S.A I.D.

Programme in Ahmedabad

Dr. K.B. Shah of the Physical Research Laboratory writes to state that the Committee for Improvement of Science Teaching are completing the PSSC course for a group of 10 selected students in Ahmedabad and a general science programme in class X, which has been carried out in 3 schools. They are also introducing new approach to the teaching of Algebra in class VIII. About 600 students of 50 different schools in Ahmedabad will take part in the experiments this year. This group is writing its own textbooks in Gujarati, to be used in this project.

Mr. Koneri, Science Teacher in the Karnatak Government High School, reports that he can teach but a small portion of the CHEM's content, he studied last summer, because his classes only run upto 10th standard However, his entire approach to teach is different. This applies not only to his teaching of Chemistry, but to the other aspects of his science teaching. He is able to incorporate much of the investigatory approach in his classes

New Delhi: An Association of Biology Teachers of Delhi was formed on February 29, 1964. About a dozen teachers gathered at the Harcourt Butler Higher Secondary School, New Delhi, at the invitation of Sri S.M Sharma. After the formal inauguration of the association Miss Katherine Bolton of the St. Thomas School gave a demonstration talk on respiration. She showed some simple experiments to develop the main concepts. All the experiments were easy to perform and could be done in a short time Miss Bolton was a participant at the Summer Institute in Biology, held at Madras in June 1963. The aim of the Association is to meet at least once a month in any one school and exchange ideas and discuss common problems. The emphasis will be on new trends of biology teaching, teaching aids, instructional materials, etc. The members may also undertake one-day field trips. This is a good beginning and it is hoped more biology teachers will join this band of pioneers. It is also hoped that teachers in other disciplines will also meet for similar purposes.

UNESCO Mission on Science Education

UNESCO MISSION ON SCIENCE EDUCATION

The Unesco Mission on Science Education (secondary stage) arrived on December 23, 1963. Following are the members of the Mission:

1. PROF. S.G. SHAPOVAEKO.
2. PROF. STEPAN BALEZIN
3. PROF. OLGA SAZONOVO
4. PROF. E. LYAPIN
5. PROF. L.S. ATANASIAN
6. PROF. G. A. PROTASOVSKY
7. PROF. V.A YAKOLIEV
8. PROF. R. BUCHSBAUM
9. PROF. PAUL HARMON KIRKPATRICK
10. PROF. FILATOV.
11. SHRI BANDOPADHYAYA

After preliminary discussions with the officers of the Ministry of Education, Members of the University Grants Commission, officers of the Council and Subject Experts from Universities and officers of the Department of Science Education, the Mission visited various Centres in two batches. The first batch accompanied by Dr. M.C. Pant, visited Lucknow, Allahabad, Calcutta and Bhubaneshwar. The second batch accompanied by Dr. R.H. Dave, visited Ajmer, Bombay, Mysore and Madras. Both the teams had discussions with the Education Secretaries and Directors of Education and they visited a number of secondary schools and teacher training colleges. The team returned to headquarters on January 20, 1964. They will be submitting their report to the UNESCO.

The team of experts left Delhi on March 10, 1964.

WORKSHOP OF BIOLOGY TEACHERS

A one-day workshop of Biology teachers of Higher Secondary Schools in Delhi was convened on January 12, 1964 at the Department of Botany, University of Delhi The workshop was inaugurated by Shri Raja Roy Singh, Joint Director, National Council of Educational Research and Training. Several panel members including the Chairman, Prof. P. Maheshwari and some teachers spoke on the various aspects of biology teaching in a secondary school. This was followed by a frank discussion of the outline, the approach to the text-book, and the difficulties experienced by the teachers in the classroom, in the laboratories, at the examination and with the administrators. Earlier, the teachers had been sent copies of the pre-publication pamphlet and three more cyclostyled chapters.

The results of the discussion are being utilized as feed-back for some revision of the chapters.

Professor P. Maheswari, Chairman, Biology Textbook Panel, addressing the participants.

Miss Katherine Bolton, St. Thomas School, speaking at the workshop.

The copies of the pre-publication pamphlet have been widely distributed to all high and higher secondary schools in the country, to Extension Service Centres, educationists, experts and others. The booklet contains a questionnaire to elicit the reactions of the teachers. Replies to the questionnaire are pouring in. These will be analysed and the views will be taken as feed-back for any further revision of the text.

SCIENCE TALENT SEARCH

The Test for this Scheme was held on February 23, 1964 (Sunday) throughout the country. There was a very good response from all the States and Territories of India. The chief feature of this year's examination was that the students were to write a Project Report. A booklet was brought out giving details of *How to develop a Project Report*. The candidates were given the option to answer the essay paper in English, or in one of the 14 regional languages. The Science Aptitude Test was set in English and the questions were of the multiple choice type. On the basis of the results of the written examination, about 2000 candidates will be called for an interview at different Centres in India Finally 350 candidates will be selected for the award of Scholarships and the next 200, in the order of merit, for the award of Certificates of Merit only. The selected students will be assisted as far as possible to get admitted into institutions of repute for studies leading towards B.Sc degree in basic sciences.

There is a proposal to hold workshops for the selected candidates in which they will be brought into contact with leading scientists and teachers in the universities. This will give the awardees, encouragement and sharpen their thirst for knowledge.

GENERAL SCIENCE TEXTBOOKS

Workshop of Authors

The Workshop of authors for writing General Science Textbooks for classes VI to VIII was held at the Department of Science Education for three days, from January 1-3, 1964. Shri Raja Roy Singh, Joint Director, N.C.E.R.T., inaugurated the Workshop. The group discussed the guidelines for the writing of General Science Textbooks prepared and circulated to the participants earlier. A number of chapters from the textbooks, foreign as well as Indian, were read out as illustrations of good lessons in support of the items included in the guideliness.

The group was of the view that the approach of the books should be modern. Facts of information should not be stated for information only but to develop concepts and principles of science, to raise questions, to lay emphasis on observation, experimentation, exploration and projects which can be easily undertaken with the help of improvised apparatus. The new spirit of science, the discovery method, should be given due importance in the writing of the units.

Five sample chapters written by the participants were read and discussed. It was felt that all the sample chapters were on the old model and must be re-written from the point of view already discussed. The chapters were thoroughly criticised and methods of improvement were suggested.

A plan for the guidebook to accompany the textbook for class VI was also discussed. To start with, the participants will write chapters for the General Science Textbooks for class VI. The participants again met in March.

Books
For your science library

The Place of Science in Primary Education. PERKINS, W. (ed.) The British Association for the Advancement of Science. 3 Sanctuary Buildings, Great South Street, London S.W 1. 1962

THIS is the proceedings of a conference organized in September 1961 under the British Association for the Advancement of Science and the Association of Teachers in Colleges Department of Education. It is a collection of the verbatim reports of the addresses to the conference session and the papers and summaries circulated. The chapters deal with: The case for bringing science into the primary school, mathematical principles in primary education; training for learning through investigations; learning through wider experience; the example of primary schools in Bristol, the development of primary science teaching in an industrial city, finding out problems associated with providing facilities for junior children, and one school solution; children seeking answers and the needs of practising teachers. An attempt has been made to sum up the discussions in the final chapter. As Sir John Wolfenden, Vice-chancellor of the Reading University has remarked in his opening address '. . .it is possible to harness the inquisitiveness of the youngs before they have had the edge of their sensibilities dullened by the banality of dull facts constantly repeated. It is also possible to harness their ceaseless activity to what might be called the elements of scientific hypothesis-making namely guessing games.

'. . . . .if (the teacher) could arrange to combine the inquisitiveness and the activity and the readiness to make a guess, then something quite close to the elements of the scientific attitude will have been acquired.'

The book is a very useful reference book for primary school science teachers, teacher educators and school administrators

General Science: Books 1,2,3, and 4. WINDRIDGE, CHARLES. Schoenfield and Sims Ltd., Huddersfield. (reprinted 1963) sh. 8/6 each

A SET of four books providing a complete course in general science for 11 to 15-year old pupils of average and above average ability in secondary schools. The course covers about equal amounts of physics, chemistry, and biology with some simple studies of mechanics, geology, astronomy and meteorology. The course is presented as a whole and there is no sharp division between the various branches of science References have been made to history, scientists and the applications of science in the home, e.g., industry, transport, medicine, public health, etc.

The book includes applications of physics and chemistry in the home and work on soils, manures, plants, animals, weather, etc.

Exercises given at the end of the books, supplement the pupils' practical work and experimental records. They give extra practice in written work, drawing, use of scientific terms, calculations, etc.

The book is profusely illustrated with simple drawings.

MRS S. DORAISWAMI

Radiation Biophysics. ANDREWS, HOWARD L. Prentice-Hall, Inc. Englewood Cliffs, New Jersey, pp. 328.

THIS book is aimed at presenting a working knowledge of radiation fundamentals to beginner students of science. It deals with the promises which the new radiation sources carry in medical diagnosis and treatment in research methods It also deals with such aspects as injury to the future generation through an accumulation of an undesirable genetic burden. Seventeen chapters in this book deal with basic principles of electronic radiation, production of X-rays, radio-activities, natural radio-activities, photon absorption, photon dosimetry, radiation measuring instru ments, radioactive assay, energy loss by charged particles, neutrons and their reactions, chemical effects of radiation, doseresponse relations in macromolecules, radiation effects in the single cell, radiation effects in mammals, pathological physiology of radiation injury, radiation health protection, etc. It is a useful book for teachers of general science.

Chemical Bonding and the Geometry of Molecules, RYSCHUEWITCH, GEORGE E. Reinhold, Reinhold Publishing Corporation, London 1962

SINCE the Sputnik, the scientists all over the world are worried about the explosion of scientific knowledge, which continues to take place since World War II. Professors and research scientists in the world are trying to find out some new methods on which various disciplines of science such as physics, chemistry, biology, etc , may be organised so that the students can reach the frontiers of science in a short span of fourteen to eighteen years, in a school and in a college. Considerable work in this direction is being done in the U.S.A., the U.S S.R., and Europe The present book is an attempt to explain the structure of the atom and chemical bonding in ionic compounds as well as covalent compounds The book can prove of immense value to teachers working in Indian high and higher secondary schools.

Radioastronomy and Radar. CROWTHER, J.G. Methuen & Co. Ltd., London W.C. 2: 1958.

IT is well known that several basic discoveries have been made with radar equipment in war time. In peace times, however, scientists use the radar in discovering the existence of radio-stars. The present book describes the designs and principles of radio telescopes and the discoveries made with them. It deals with the origin of radar, electrical mirror, cathode ray tube, short-waves, the magnetion, radio-telescope, radio-stars, resolution, radio-spectroscopy, colliding galaxies, the Mullard Observatory and allied aspects of radio-astronomy. It is a valuable introduction to the science of radio-astronomy for beginners

V N. WANCHOO

Handbook of Nature Study. COMSTOCK, ANNA BOTAFORD. 24ed. 17th printing. Comstock Publishing Associates. Constable & Co Ltd London W.C. 2. 1960 pp. xxxx 937.

A TEXTBOOK on science may become out of date a few years after its publication. A good monograph or a review on a particular branch or aspect of research work may also become out of date, as science is advancing rapidly and new facts are being added to our knowledge But some books remain classics however old they may be *Handbook of Nature Study* by Comstock is one such. This classic work on nature study was first published in 1911, and the 24th edition in 1939, has had seventeen reprints. The usefulness and the popularity of the book can be judged by this record This book has been used as a text, reference book or as general science information by hundreds of thousands of students, teachers and parents.

The individual organism is studied in its environment, its relation to the world about it and the features which enable it to function in its surroundings. The subjects treated include birds, fishes reptiles, amphibians, mammals, insects, flowers, weeds, flowerless plants, cultivated crop plants and trees There is also a section on Earth and Sky, which deals with brooks, rocks and minerals, soil and soil conservation, magnetism, the stars and weather. Each subject is discussed as a lesson with a thorough treatment of a particular organism or phenomenon and contains a leading idea to be emphasised by the teacher and to be developed by the pupil later through personal observation.

Nature study is an aesthetic experience as well as a discipline. It means a broadening of intellectual outlook, an expansion of sympathy and a fuller life. The chief virtue of the book lies in the fact that the author has succeeded in conveying these in her work But nature study is also a science. Ecology is merely a formalized nature-study. It is not merely a study of life, but an experience of life.

The children are eager for nature study unless it is spoiled in the teaching. But with a book like this in his hand any teacher can make nature study very interesting

The book is profusely illustrated with five photographs and drawings besides the 17 full-page plates. It is a book which will be valuable in any school library

The Hidden Life of Flowers. GUILCHER, J.M. (Translation from the French text). Andrew Melrose, London, 1954. pp. 93.

How does life begin?' This is one of the most absorbing problems of biology. This book, *The Hidden Life of Flowers*, attempts to answer this question by telling the story of the birth of plants through a number of brilliant photographs, over one hundred in number. The pictures show reproductive organs, fertilization and the formation of seed in several common plants. The text is merely added to guide the study of the reader.

Life's Key—DNA. A Biological Adventure into the Unknown. HUTCHINS CARLEEN M. Coward McCann, Inc., New York: 1961. pp. 64.

DNA is one of the nucleic acids present in every cell in our body, as well as in the cells of all animals and plants. *Life's Key—DNA* describes very effectively and forcefully the facts that are now

known about this remarkable substance, and the role it plays in heredity. This is one of the exciting areas of modern scientific research and the recent developments in the studies of DNA open wide horizons into the wonder and complexity of biology of plants and animals and man himself In recent researches in virology, biochemistry and molecular biology and particularly in the study of nucleic acid, man has moved closer to the core of the mystery of life, has probed more deeply, has moved faster and farther than through all the centuries that lie behind him. That we have reached the point where we can study life in terms of molecules is in itself a marker of history bearing more weight to human density than the hydrogen bomb or our rockets into space.

The ideas in this book are offered in the light of recent evidence available from research laboratories throughout the world.

The nucleic acids have become the foundations of a subdivision of science known as molecular biology and DNA is the most exciting biological discovery of the twentieth century. With this discovery a new era is opening for the understanding and control of the biological processes within the living cell.

The salient feature of the subject is treated in a simple way with good illustrations so that even a lay man reading the book gets an idea of what is DNA, how it works, what is it made of (Chemistry), how is it put together (geometry of DNA), how it carries hereditary information, how do changes in heredity occur (mutations), and how does DNA help build proteins.

Finally the author also describes a method to make your take-apart model of DNA. The subject is much more complex than what a reader can make out of the book which only serves as an introduction which will awaken further curiosity and inquiry.

Basic Ecology: BUCHSBAUM, RALPH and MILDERED. The Boxwood Press, Pittsburgh, Pennsylvania: 1957 (reprinted 1964) pp ix+195.

THE world is facing now many problems like population increase, depletion of natural resources, water and air pollution, natural calamities like floods, drought and dust storms. Wise use of land and our forest resources, conservation of the soil and construction of multipurpose dams are all matters which a citizen must understand and in which he must have an informed opinion. Foundations for such opinions can be built up only by a knowledge of biology in which ecology forms an important part. General textbooks of biology do not have more than a short chapter on ecology. Further reading materials which could be used for supplementing the lessons in a classroom are absolutely necessary. The authors have in their *Basic Ecology*, provided us such thought provoking and vivid supplementary reading material useful to biology teachers, and students of colleges and schools.

The authors begin with a description of what is ecology and go on to describe the physical and living environments, the communities, succession and distribution of plants and animals. Important as the contents are the presentation and method of approach are interesting and dynamic. They make the study of ecology very interesting, for after all man as a part of the animal world is interesting in his

environment, and how it affects him and the other living things on earth

The book has been neatly produced and the illustrations are excellent. The cover page has a meaning and it depicts a food pyramid with a vulture on top and above this is a 'reverse' pyramid of parasities and microbes This is a telling way of showing how interdependent the living beings are and how the cycle of changes go on for ever. Life from this earth and the organic matter back to earth

More Simple Science. Earth and Man. ANDRADE, E.N.DA C. and HUXLEY, JULIAN. Basil Blackwell. Oxford pp x+342. 1949.

THE material of this book is written for young people to serve as an introduction to the more specialised study of science. The science presented is not a 'School Subject' but a living body of knowledge which interact with everything around us. Many examples are taken from the world outside

After describing Earth, its history and climate, chemistry of life is taken and then soil, agriculture, stream of life (about animals), and the improvement of living things. (Heredity, environment and breeding.) The last chapter on the 'History of Science' gives the reader a good account of the progress of science and its present position. The book makes a good reading and the teacher and student will find quite a number of interesting facts in spite of the book being a dozen years old. S. DORAISWAMI

New Ways in Math. JONAS, ARTHUR, Prentice Hall, Inc., Englewood Cliffs, N. J: $ 2.95.

HERE is a story of mathematics and why man bothered himself with numbers. It begins with cave man's bartering and traces the history of the development of the subject up to the space age. The contribution made by the Romans, the Egyptians and Hindus are explained in simple language and are really informative and interesting. Importance of zero and its different meanings in mathematics is explained by different illustrations, the use of computors in solving problems that face science have been explained in detail. Multiplication and division without using multiplication tables and working in binary numbers is just plain fun. Discoveries made by mathematicians like Pythagoras, Archimedes, Newton and Einstein are explained in simple and lucid language.

New Ways in Math is a book which all beginners in mathematics should go through Young readers will find adventure in every page and know something about the history of mathematics and the scientists who helped develop it.

50 Mathematical Puzzles and Oddities. SCRIPTURE, NICHOLAS E. Faber and Faber Ltd., London W. C. 1: pp. 88, 12s. 6d.

THIS little book with 50 puzzles and oddities will prove helpful in making arithmetic, algebra and geometry not only interesting but also amusing and entertaining There are 50 oddments in all, 23 in arithmetic, 8 in algebra and 12 in geometry. Seven miscellaneous oddments and answers are added at the end. In arithmetic, 'Russian multiplications, squaring of numbers, test in divisibility, converting fractions into decimal forms are all amusing. In algebra multiplication of like signs, Fermat's Last

Theorem and 'Directed Number Rule' are sufficient enough to enliven lessons generally found uninteresting and dull in classroom. Pythagoras Theorem in geometry has been proved in different ways and a few puzzles added to it. Finding the relationship between the diameter of a circle and its circumference is all the more entertaining.

The reasoning and the explanation of all the puzzles and oddities are logical and simple and therefore, the book is recommended both for the teachers and the taught.

J.N KALLA

Basic Electricity. ABRAHAM MARCUS. George Allen and Unwin Ltd., London : 1962. pp. 493.

THIS book on the fundamentals of electricity is intended for beginners and presumes no background knowledge of physics or mathematics What is assumed on the part of the reader is simple arithmetic. It presents a content based on well connected concepts, the sequence of which has been nicely planned to enable the reader to understand the subject.

While presenting a new concept the author has kept in mind that the gap between the new information and what the reader knows is not wide, rather the new ideas have been presented as an extension of the knowledge about electricity of the reader. This discovery method, approach and proper organization has made the book pedagogically sound.

The book is divided into six sections; the first one introduces the subject through the enquiry—'what is electricity.' The second one deals with direct current pohenmena, and in the third and the fourth are discussed alternating current and generators of electricity respectively. Different types of sources of electricity—mechanical and chemical and others, besides the most recent ones such as the solar and atomic type are all dealt with in one section. The applications of electicity based upon thermal, the luminous, chemical and magnetic effects are discussed in section V. The sixth section deals with the electronic tube, transistor and their applications in various fields. This section constitutes what is generally known as electronics and makes this book on electricity a composite text.

Mention must be made of the well-planned set of questions at the end of each chapter and various useful glossaries of electrical terms, units, abbreviations, formulae and graphic symbols besides tables of essential information given in the appendices. The book with a good number of line diagrams and photographs which a reader is not likely to come across easily in the schools should be highly useful to students.

Let's Explore with the Electron. BENDER, ALFRED Sentinel Books Publishers, Inc. 1960. pp. 126.

THIS book presents the theory of electricity and its production in a simple way. There are 151 diagrams to enable the reader to understand the ideas and the equipment introduced. There are detailed suggestions for the reader to carry out some projects of his own like making of Van de Graaff Generator, Galvanometer, Electric Motor, Photo-electric Relay and Electric Thermometer. Electricity can best be understood by doing and this book will be thoroughly useful

for those beginners who want to learn electricity in an easy way.

K. J. KHURANA

The Mighty Atom. LEWELLEN JOHN. KNOPF, ALFRED A. Inc., 1955: pp. 59.

THIS book explains about the tiny and invisible atoms and how these can be combined to make chemical compounds in a simple pictorial way. It also explains how the energy in the centre of the atom is released in an atomic bomb or in a nuclear power plant. Some figures and pictures given arouse the curiosity of the young students to know more about the things around them. This book contains chapters on the 'Mighty Atom : Inside the Atom , 'How atoms are built': 'How Nature makes everything from atoms', 'The power in the centre of the atoms' and 'Atomic furnaces and engines'. The author has clarified the ideas like fusion and fission in a simple way. This book will be useful for the students of the Indian schools.

You and the Sciences of Plants, Animals and the Earth. BROEKEL, RAY. Children Press U.S.A: 1956. pp. 60.

THE book has explanations of how the different sciences got their names and what these are. The author has tried to explain in the form of charts along with pictures the names of the specialized sciences and sub-sciences, and also what people do, who work in the specialized fields of these sciences. The relationship of one field of science to another and their interdependence has also been given in a simple way. Sciences like biology, geology with their related branches, chemistry and physics and their branches, and astronomy which are related to the things around us are dealt with.

K.S. BHANDARI

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(Sd.) P.N. NATU
Signature of Publisher

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Early Achievements by Different Nations in Science

N.R. DHAR

Sheila Dhar Institute of Soil Science, Allahabad University

THE famous English historian, A.J. Toynbee, several years ago concluded that at least 21 great civilizations rose and fell during the last 6000 years of human progress. From a detailed historical survey he was convinced that the next big World War is likely to start round about Tibet. Undoubtedly, these civilizations had developed arts and crafts considerably.

Along with the Chinese civilization about 4000 years ago, three other big civilizations, the Egyptian, the Babylonian and the Indus Valley, were in full swing, and marked progress in useful arts and craftmanship was achieved. With improvement in arts and crafts, the rudiments of science and medicine made their appearance.

The invention of writing was contemporary with the early days of the Egyptian civilization and, soon afterwards, treatises on crafts were written and these formed the nucleus of recorded applied science Prof. J.R. Partington, in his *Origins and Development of Applied Chemistry (1931)*, has recorded the early achievements in the production and uses of numerous inorganic and organic materials in Egypt, Babylonia, Assyria, the Aegean, Asia Minor, Persia (Iran), Syria and Palestine. He was unable to take up Indian and Chinese contributions as he felt that adequate information was not available due to these countries being very far from Europe.

The eminent Belgian specialist in the history of sciences, Prof. G. Sarton, in his book *The Guide to the History of Science*, has emphasized that the history of ancient and medieval science is largely a history of tradition A good deal of the achievements of alchemists, physicians and craftsmen was transmitted by manual examples to their pupils The teacher would say: 'Watch me, see what I am doing and how I am doing it and do the same'. Acharya P.C. Ray, in his *History of Hindu Chemistry*, had laid stress on the same aspect of the development of applied science.

Science in Different Civilizations

Sarton has drawn the following graph symbolising the progress of science in different civilizations.

The roots of western science are Egyptian, Mesopotamian and to a much smaller extent Iranian and Hindu. The new arithmetic and the new trigonometry were due to the mutual fertilization of two very different streams of thought, the Greek and the Hindu. The graph shows that the Arabic achievement is not only a continuation of Greek science but also

of Iranian and Hindu ideas. It is interesting to note that Sarton is defi-

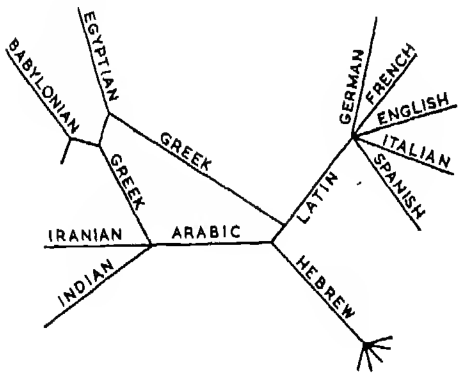

Fig. 1

nitely of the opinion that western science was not influenced by the Chinese.

Regarding Arabic progress, G. Sarton has stated: 'The best Arabic scientists were not satisfied with the Greek and Hindu sciences which they inherited. They facilitated the evolution of algebra and trigonometry and prepared the way for the European algebra of the 16th century. The Arabic culture is a bridge, the main bridge, between the East and the West. It is through that bridge that the Hindu numerals, sines and cosines and the Chinese silk, paper, porcelain reached Europe. Latin culture was western, Chinese culture was eastern, but Arabic culture was both.'

There is no doubt that under the inspiration of the Prophet and his followers, Arabic culture, science and technology made tremendous progress, and have spread in the east and west. Similarly, in the Buddhist period, there was a grand creation of new knowledge and its applications in India and these were carried to many Asiatic countries and took roots in the soils of foreign lands

H.M. Leicester and H.S. Klickstein, in their book *Source Book in Chemistry—1100-1900* (1950), have observed: 'With the decline of the Alexandrian culture the learning of the Greeks passed by way of Syria to the Arabs. They received ideas not only from the west but also from India and China. A Chinese form of alchemy had existed from almost the same period as the Greek, and the Chinese sages sought to prepare a medicine from which gold could be formed. This may have been the origin of the idea of the Philosopher's Stone, which is not mentioned by the Greeks. In the 12th and 13th centuries, the science of the Arabs passed at an increasing rate back to western Europe.'

The astronomy of the ancients consisted chiefly in observing the position of the heavenly bodies and the Egyptians and Babylonians were interested in astronomical observations as aids to astrology and preparation of calendars. The practical needs of architecure and surveying led to the study of geometry, and areas and volumes were computed. Babylonian arithmetic was well advanced. Logic and interest in pure knowledge started with the Indians and Greeks. Biology began with Aristotle (4th century B.C.), but the practice of medicine and surgery was in vogue from time immemorial. In Egypt, as early as 3000 B.C., the physician was highly respected.

F. Sherwood Taylor, in his book *A Short History of Science*, 1950, has recorded: 'It is quite certain that a high state of intellectual development existed between 700 B.C. and 500 A.D. in India. In Sanskrit, the Indian had a language capable of expressing with accuracy the most subtle shades of meaning. The Indian genius was psychological and no other people has

evolved so systematic a vocabulary of terms for the expression of the states of mind. The first philosophical system may have come into being at much the same time as the beginning of the Greek philosophy, namely, between the 8th and 5th century B.C. Indian medicine had a long armoury of drugs, many of which seem to have been potent. The real merit of the Indian scientific culture is to be found in its mathematics. The Indian genius tended towards arithmetic and algebra rather than geometry. The Arabs certainly gained mathematical knowledge from India *before* they had access to any of the great Greek mathematical authors'.

Describing the Chinese achievements, Taylor observed: 'The Chinese culture arose at an early date which may be in the region of 3000 B.C. The genius of the Chinese has not proved itself a scientific one, though, from the earliest times, they have excelled in arts and technology. The influence of India on China was, of course, considerable. The Chinese mathematicians never reached the standard of their Indian teachers.' As we have been now forced to be very alert about China, the foregoing observations are of considerable significance to ourselves for our uplift.

Contributions From India

It appears, therefore, that in the early days of our civilization, say about 400 B.C., India produced almost as good thinkers as Greece. We had at this time Kanada and Kapila whilst Greece had Aristotle and Democritus. All these seers speculated on the ultimate particles of matter known as atom. But, as there was no experimental support for their views, not much progress was achieved. Our Jivaka, about A.D. 2 and Nagarjuna, A.D. 750 were perhaps better scientists than those existing in Europe up to 7th or 8th century A.D. specially from the practical point of view.

The iron pillar used in the Kutab Minar and those in other parts of India, forged and constructed about the 8th century A.D. or earlier, consist of practically pure iron. They have attracted universal admiration and even great modern scientists like Prof. H. Le Chatelier of Paris and Sir Robert Hadfield of England have recorded their great appreciation of this Indian achievement. Sir Robert has stated: 'Indeed it is only within the last century or so that any European iron master could have undertaken to produce such a forging.' The result of the analysis by him is as follows.

Carbon	Silicon	Sulphur	Phosphorus
0.08%	0.046%	0.006%	0.114%
Manganese	Iron	Specific gravity	
nil	99.72%	7.81	

Similarly, the preparation of caustic alkali and the internal use of iron and mercury compounds as medicine were known in India earlier than in Europe. But, the difficulty for the historians in India has been aptly put by A. Sprengler in his famous book *Decline of the West* that the Hindu has not recorded anything even if the matter is of a great national or cultural importance whilst the Egyptian has put down all his progress and achievement.

China and Greece

It is well known that the Chinese knew of gun powder in the 6th century A.D., and the use of coal before the Europeans. It is believed that the Chinese were good at bridge building, hydraulic engineering

and in enamel and lacquerware. It is interesting to note that the Greeks, who were the acknowledged leaders of thought, philosophy and culture in Europe, continued their mental vigour between the 6th century B.C. and the decay of the Alexandrian Museum in the 2nd century A.D. The history of the Byzantine Empire showed that the Hellenic world was intellectually stagnant for 1000 years as it happened perhaps in India and China. It is known precisely that there was no progress in Italy during the Roman period, but, it became very fertile since the renaissance of learning. The English mind was fairly bright in the 7th and 8th centuries A.D. but remained dormant for nearly 700 years and started reshining in the 15th century. Moreover, the ability of the Arabs was very apparent for 150 years after the appearance of Islam, but, remained inactive almost uptil now The Chinese continued their inventiveness in their art.

Aristotle was the tutor of Alexander the Great for several years in the Court of Alexander's father, Philip of Macedonia. Aristotle anticipated Bacon and the modern scientific movement as he was a great pioneer in observing Nature in all its phase and drawing conclusion from observations. Other men followed the easy path of speculation. His pupil, Alexander the Great, contributed hundreds of talents (1 talent is equivalent to £240/-) for carrying on experimental observation by Aristotle and his pupils who numbered 1000, distributed in Greece and Asia, for collecting materials for his *Natural History*. This seems to be the beginning of organised scientific inquiry. In Egypt, at the Alexandrian Museum, this work was continued after Alexander's death for some time. Unfortunately, this method of obtaining new knowledge by painstaking observations and experiments was not continued in Greece after the 4th century B.C The Stoics and Epicureans only cared for ethics, that is, the practical question how a man should order his life, and neglected experimental inquiry which is difficult and laborious. Thus again, speculation and discussion ruled the world of learning till the experimental methods were reorganised in north-west Europe in the 13th and 14th centuries. Before this development, political, economic and religious conflicts between Europe and Western Asia were rife and intellectual effort was frustrated. The Semitic people rose against the Aryans and replaced Greek culture and civilization by Arab influence. All Western Asia and almost half of Europe came under the Mongolian rule, but this influence of invasion did not last very long in Western Europe as it did in India. In the field of the revival of intellectual efforts and freedom of thought, notably in the Universities of Paris, Oxford and Bologna, Peter Abelard (1079-1142), Albertus Magnus (1193-1280), Thomas Aquinas (1225-1274) and specially Roger Bacon (1210-1293), a clever Franciscan monk of Oxford who studied both in Oxford and Paris Universities, played a very important role. He insisted upon the need of experimentation and collecting knowledge on the same lines as Aristotle. He shouted to mankind and said 'Cease to be ruled by dogmas and authorities. Look at the world.'

After the 8th century A.D. we in this country never carried on experiments and never accepted the experimental method of science This seems to be the main reason why we are backward and not so honest in our efforts and actions as an

European who has developed more method and honesty in everyday life We have been very unlucky because invaders came repeatedly to our land and enslaved us Instead of following the path of truth, progress and science, we succumbed to moral and mental slavery and, I am sorry to say, this mental slavery seems to be persisting.

Experimental Methods

During the 15th and the 16th centuries, the experimental method of science was gradually established in Europe by Paracelsus, Bacon, Boyle, Palissy and many others. They were followed by Black, Scheele, Priestley, Newton, Cavendish, Davy, Berzelius, Bunsen, Mendeleef, Darwin, Mendel, Dumas, Bossingault, Faraday, Pasteur, Ross, Koch, Madame Curie and others who made tremendous sacrifice in pursuing scientific endeavour and experiments. They applied science to all problems of life and developed their natural resources, improved their agriculture and made Europe prosperous. There was marked progress of science and technology for nearly 500 years.

The age of modern science in India is approximately 60 years whilst in North-West Europe scientists have toiled for nearly 500 years. Hence, we have to be patient and work hard for our national uplift.

Our Units of Measurement—II

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IN the first part (Pathria, 1964) an attempt was made to review the sequence of steps that finally led to the adoption of the so-called optical metre as the fundamental unit of length measurement. In the present article it is proposed to discuss the corresponding situation in regard to the fundamental units of mass and time. From a strictly physical point of view, we should first consider the unit of time and only then the unit of mass. The sole reason for the reverse order chosen here is that it will provide a decidedly better continuity of narration from the first article to the present one.

THE UNIT OF MASS

Before the time of Galileo (1564-1642) and Newton (1642-1727) there were no standards of 'mass' as such. Of course, there were plenty of standard 'weights' even two thousand years previously. From the very early times the beam balance, in a primitive form, was being employed for the comparison of weights, and for many centuries it was intuitively, though not explicitly, assumed that by this procedure one indeed compared the intrinsic quantities of the materials involved. The modern man does indeed understand things better but the practical position with regard to the problem of comparing masses remains essentially the same. Thus, even now the most practical way of comparing masses is no other than that of comparing the respective weights. Having recognized that, the next problem one has to face is to define an appropriate unit which could be regarded as the fundamental universal standard of mass and to which all practical measurements of this quantity could be referred.

As has already been described in Part I, the grand scheme set out in the French law of 1799 adopted one ten-millionth part of the Earth's quadrant as the fundamental unit of length. A material representation of this unit was deposited in the National Archives and given the name *Metre des Archives*. At the same time it was decided to fix the fundamental unit of mass jointly by the dimensions of the Earth and the physical properties of pure water. The desired unit was defined as the mass of one cubic decimetre of pure water at its temperature of maximum density (which is very nearly 4°C), and the name *kilogramme* was given to it. A platinum standard intended to serve as the material representation of this unit was prepared by Le Fevre, Gineau and Febroni, and was deposited in the Archives in company with the Metre. Technically, this mass standard is referred to as the *Kilogramme des Archives.*

Incidentally, for purposes of liquid measure, the name *litre* was given to the volume unit of one cubic decimetre; thus, *by definition*, one litre of pure water at its

temperature of maximum density had a mass of one kilogramme.

The Archives standard, however, could not continue indefinitely; it had to yield place to the so-called *International Prototype Kilogramme*. The story of this transfer of honour from one standard to the other is precisely the same as in the case of the Metre; hence, there is no point in repeating it here (see Part I). Suffice it to say that since 1889 the kilogramme is officially represented by a fundamental prototype standard which has been established at the International Bureau of Weights and Measures, Sevres. This standard is in the form of a solid cylinder (made of the Johnson-Matthey alloy), having a diameter essentially the same as its height (about 39 mm), with edges very slightly rounded. The arrangements for its preservation and for the disposal and maintenance of its copies are the same as for the Prototype Metre.

With both metre and kilogramme redefined, it became very natural to enquire if one cubic decimetre of pure water, at its temperature of maximum density, did really have a mass *exactly* equal to one kilogramme. Measurements showed that it was not so. In fact, the new standard of mass turned out to be 28 parts in a million greater than the mass of a cubic decimetre of pure water at its temperature of maximum density, the latter being the previous definition of the mass standard. Thus, a litre could not be (i) a cubic decimetre and, at the same time, (ii) the volume of one kilogramme of pure water at its temperature of maximum density. In 1901, this conflicting position was clarified by specifically adopting the definition (ii) for the litre, so that we now have: 1 litre=1.000028 cubic decimetre. Correspondingly, 1 millilitre (ml) is equal to 1.000028 cubic centimetre (cc). It may be mentioned in this connection that the 11th General Conference of Weights and Measures, which met in Paris in October 1960, has invited the International Committee to study and, if possible, resolve the confusing situation arising due to the aforementioned difference between two nearly equal units of liquid measure.

THE YARD AND THE POUND

It does not appear to be out of place to make here a brief mention of the Imperial units of length and mass and of their relationship with their metric counterparts. The importance of these units lies in the fact that they are used practically in all non-metric measurements in science and technology.

Established by the British Weights and Measures Act of 1856 and explicitly defined by a similar Act of 1878, the *Imperial Standard Yard* is represented by the distance between two transverse graduation lines on a bar of square cross-section, made of bronze alloy (known as Baily's metal: 16 parts of copper, 2½ parts of tin and 1 part of zinc), when the bar is at 62°F and is supported on eight equally spaced rollers. This yard standard is preserved at the Standard Weights and Measures Department of the Board of Trade. There are five parliamentary copies as well, which are deposited with some of the premier institutions of Great Britain.

Repeated determinations, carried out by the National Physical Laboratory of England, have shown that, from the point of view of preservation of the unit of length, the British standard has been

rather inferior to the French standard. This lack of reliability was one of the main reasons for the adoption, in 1959, of the so-called *International Yard*, defined (by agreement between the United States and the British Commonwealth) through the permanent definition, namely 1 yard=0 9144 metre.

Correspondingly, we have the *Imperial Standard Pound*, which is represented by the mass of a cylinder of platinum, of diameter slightly less than its height, provided with a shallow groove round its cylindrical surface (meant for engagement with an ivory lifting fork). The arrangements for preservation and for disposal and maintenance of the five 'parliamentary' copies of this standard are the same as in the case of the corresponding unit of length. Again, in view of some lack of reliability,* and for other reasons as well, an *International Pound* was adopted in 1959 This, through a permanent definition, equals 0,45359237 kg.

THE UNIT OF TIME

The physical reality to which the notion of time relates is so all-pervasive that it is impossible to describe any human activity without a direct or indirect reference to it. The beginning of any experiment occurs *before* its end, and the experiment itself is assumed to occupy a certain definite time interval. Observations such as this show that, for any observer, the various physical events that take place in the universe can be arranged in an unambiguous order governed by the concepts of *before*, *after* and *simultaneous* According to the German mathematician and philosopher Leibnitz (1646–1716), 'Space is the abstract of all relations of co-existence. Time is the abstract of all relations of sequence'.

Now, the primary problem of interest here consists in the selection of a standard time-keeping device, with reference to which the duration of any particular time interval could be reliably ascertained. Such a time-keeper could very well be the rotation (or revolution) of the Earth, the oscillation of a free pendulum or of a flat spiral spring, the emission of radiation by an atomic system, or the vibration of a crystal of quartz The most essential pre-requisite for the intended purpose would, of course, be that the assumption of the constancy of recurrence interval of the periodic process involved be strictly valid.

From the very earliest of times the rotation of the Earth on its axis has been the most obvious choice as the common standard of time-keeping And it has indeed proved to be a very good choice. In this connection, we have, first of all, the *solar day*, which is reckoned as the interval between two successive transits of the Sun across the meridian; this, however, varies throughout the year. The astronomers, therefore, introduced the so-called *mean solar day*, this was defined in reference to a fictitious sun 'moving' uniformly through the 'fixed' stars, the speed of motion being equal to the average speed of the true Sun The fundamental unit of time—the *second*—was then defined as 1/86400 of a mean solar day.

Obviously, any time system based on the rotation of the Earth will be uniform

*It may be mentioned here that certain pound-kilogramme comparisons carried out at the British N P L., during the period 1960–61, showed that the Imperial Standard Pound had increased by about 1 part in 10^7 since 1932, when this comparison was last made.

only if the rate of rotation is itself uniform. However, it is now known that this condition is not strictly fulfilled. Using quartz clocks (to be described a little later) as time-standards, the period of rotation of the Earth has been found to show seasonal variations of the order of microseconds. There is also a secular variation caused possibly by tidal friction It has been estimated that our astronomical unit of time has varied during the last hundred years by about 7 parts in 10^8 (there is, of course, good evidence that during a year the unit is uniform to about 4 parts in 10^9).

Accordingly, a new time-standard, called the *Ephemeris Time*, has been adopted, this one is based on the period of revolution of the Earth around the Sun. Unfortunately, this again is not strictly constant, hence, the length of a specific year has been chosen. Thus, on October 14, 1960, the 11th General Conference of Weights and Measures confirmed the action of the International Committee of Weights and Measures in replacing the older definition of the second by re-defining it as 1/31556925.9747 of the tropical year 1900. This decision effectively freezes the definition of the second in terms of the mean solar day of the year 1900, and so makes it independent of the secular changes in the Earth's motion. It should be noted that it is only the second of the ephemeris time that is now to be referred to as *the second*. Further, it appears of interest to point out that the new second is shorter, by about 2 parts in 10^8, than the previously defined second (as pertaining to the present epoch); this, however, does not raise any practical questions about the continuity of usage.

In contrast to the standards of length and mass measurement, the second obviously cannot be kept in safe deposit with any institution, its relation to the current measures of time has got to be secured only by means of tables cataloguing the apparent motion of the Sun. In practice, it is more convenient to make observations on the Moon and employ a lunar ephemeris (table of the predicted positions of the Moon) accurately related to the calculated motions of the Sun.

THE LABORATORY STANDARDS OF TIME KEEPING

It would, of course, be preferable if one could have a time standard based on a mechanism which is easily reproducible and, at the same time, sufficiently reliable. For this, an atomic clock immediately comes to mind. Such a clock is a means of measuring time intervals in terms of the characteristic periods of certain molecules or atoms. As is well known, the transition between the energy states E_1 and E_2 of an atomic system is accompanied by the emission (or absorption) of radiation having a frequency given by $h\nu=(E_2-E_1)$, where h is Planck's constant. Any spectral line thus provides a frequency ν which is a physical constant; of course, to be useful as a standard it must fall in the range of frequencies which can be related to the laboratory oscillators/clocks, and it must be of a sufficiently precise determination and definition.

Now, time-keepers based on the quartz-crystal oscillators have also been in use for quite some time. These clocks operate with such a uniformity of rate that their inter-comparisons can be made with a precision of about 1 part in 10^{10}. Two standard quartz clocks are maintained at the British N.P.L., where much of the pioneer work in their develop-

ment was done. At the same time, an atomic clock based on the frequency of a particular spectral line of caesium has also been developed there. The comparison between the quartz clock and the atomic clock has also been carried out with an accuracy of about 1 part in 10^{10}, the final mean value for the frequency of the caesium line in question comes out to be 9.19263177×10^9 per (ephemeris) second. This frequency, being a fundamental atomic constant, is practically unaffected by external conditions.

It is estimated that it would take about ten years of astronomical readings to reduce measurements of the second to an accuracy of 5 parts in 10^{10}. Hence, the implementation of the official definition of the Ephemeris Standard appears to require the use of at least atomic clock standards. One rather hopes that ultimately the ephemeris second will itself be replaced by an 'atomic' second, defined in terms of the period of an atomic clock, such as the caesium clock. In this connection, the understandable reluctance to break with a practice as old as civilization has got to be appreciated But a consideration of the precision of measurements and the necessity of ready reproduction of standards alone shows that the present unit of time may not for long remain suited for advanced measurements of frequencies and time intervals.

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The Fungi in Human Economy

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THE biologist uses the term 'fungi' (singular: 'fungus') to include the moulds and mildews, the yeasts, the rusts, smuts and bunts, the mushrooms, toad-stools and puff-balls and the like. In a loose way of speaking, the ray-moulds (Actinomycetes) could also be included in this assemblage, for though not true fungi, they are very closely related to them. The fungi are colourless plants which cannot manufacture their own food and hence live either as saprophytes, breaking down organic matter into its simpler constituents and then using them for their nourishment, or as parasites, attacking other living organisms and feeding on them, and their impact on human economy, which is the subject of this article, stems from these two aspects of their activity.

Though the systematic and scientific study of the fungi is only about 250 years old, the manifestations of this group of organisms have been known to man for thousands of years—ever since the first sip of fermented drink and the baking of the first loaf of leavened bread. But yet, it is surprising that even in this science-conscious world, where the atom and its nucleus are household words, only a few realise how intimately our lives are linked with those of the fungi. It would be no exaggeration to say that scarcely a day passes during which we are not harmed or benefitted, directly or indirectly, by these organisms.

As a result of their widespread occurrence and astonishingly large numbers, the fungi play a very important part in the slow but constant changes taking place around us. The saprophytic fungi are an indispensable element in maintaining the balance of nature. Not only do they act as scavengers by preventing undue and harmful accumulation of dead plant and animal matter, but they also enrich the soil by breaking down this dead waste and inducing various changes which ultimately result in the release of simple substances in a form readily available for the sustenance of other plant and animal life, thus playing vital role in the cycle of life on this planet.

The saprophytic fungi are also quite important from the industrial standpoint. As early as 1867 the French scientist van Tieghem showed that the common mould *Aspergillus niger* could convert the tannin of gall-nuts into gallic acid. Even today considerable amounts of this acid which finds important industrial uses in the manufacture of inks, dyestuffs and other chemicals, are produced by mould fermentation. Production of citric and oxalic acids by similar mould fermentation is also an equally old and well-established industry. Other important organic acids produced by mould

are gluconic acid, lactic acid, fumaric acid, kojic acid, itaconic acid, etc., and these are obtained mostly from species of the common moulds *Rhizopus*, *Aspergillus* and *Penicillium*. During the two world wars, moulds were used for fat production by the Germans with considerable success.

Vitamins and enzymes are also produced by some of the fungi in large quantities. Enzymes like amylases, catalases, pectolytic enzymes, etc., and vitamins like riboflavin, vitamin B_{12} and vitamin D are now produced on a commercial scale by fungal fermentation in many countries including our own.

Alcoholic fermentation by yeasts and other moulds has been known to man from the earliest times. In the Vedas and other ancient literature, we find mention of *soma*, a ritual alcoholic drink. Starting as a crude process, the technique of fermentation has now been refined into a scientific and well-developed process, furnishing a wide array of alcoholic products useful to the scientist, industrialist and common man alike.

The most important and spectacular products of fungal fermentation, however, are the antibiotics Sir Alexander Fleming's chance discovery of the antibiotic activity of *Penicillium* in 1929 and the subsequent chain of events which led to the isolation, purification and commerical production of penicillin are too well known by now to need special mention. Spurred on by this discovery, investigators in many laboratories embarked on an unprecedented search for similar antibiotics, and as a result, we have today a large number of antibiotics available for combating diseases of man, animals and plants. The later discovered and more powerful 'broad spectrum' antibiotics like streptomycin, chloromycetin, aureomycin, terramycin, ilotycin, neomycin, etc., are the products of the ray moulds (Actinomycetes) which are not true fungi but closely allied to them Today, many factories all over the world are devoted to the production of these antibiotics which have proved to be the most powerful weapons in mankind's unending fight against disease. In our own country we have a number of factories, both in the public and private sectors, contributing their share. The latest addition to this growing family of antibiotics is 'Hamycin', a product of the government spornsored Hindustan Antibiotics Ltd., Pimpri. The antibiotic has been found particularly useful against skin diseases caused by fungi.

The gibberellins and gibberellic acid are a group of remarkable growth-promoting substances produced by the fungus *Gibberella fujikuroi*. Both in laboratory experiments and in actual practice these hormone-like substances have given spectacular results in increasing the size of plants and fruits, inducing early and abundant flowering, production of seedless fruits, increase in the amount of active principle contained in medicinal plants, etc. Several manufacturers are at present producing gibberellic acid and the gibberellins in marketable quantities by using fermentation techniques similar to those employed for the production of penicillin and other antibiotics.

Many of the larger fungi are edible and have been used by man as food and medicine since pre-historic times. In the Orient, particularly in China and Japan, fungi have been esteemed for centuries as delicacies and also as remedies for various ailments, The ancient Romans

knew and distinguished various edible and poisonous fungi (mushrooms and toadstools) It is said that the Emperor Nero was particularly fond of mushrooms. In many western and eastern countries the mushrooms, morels, truffles and puff-balls are prized as delicacies and widely cultivated and marketed.

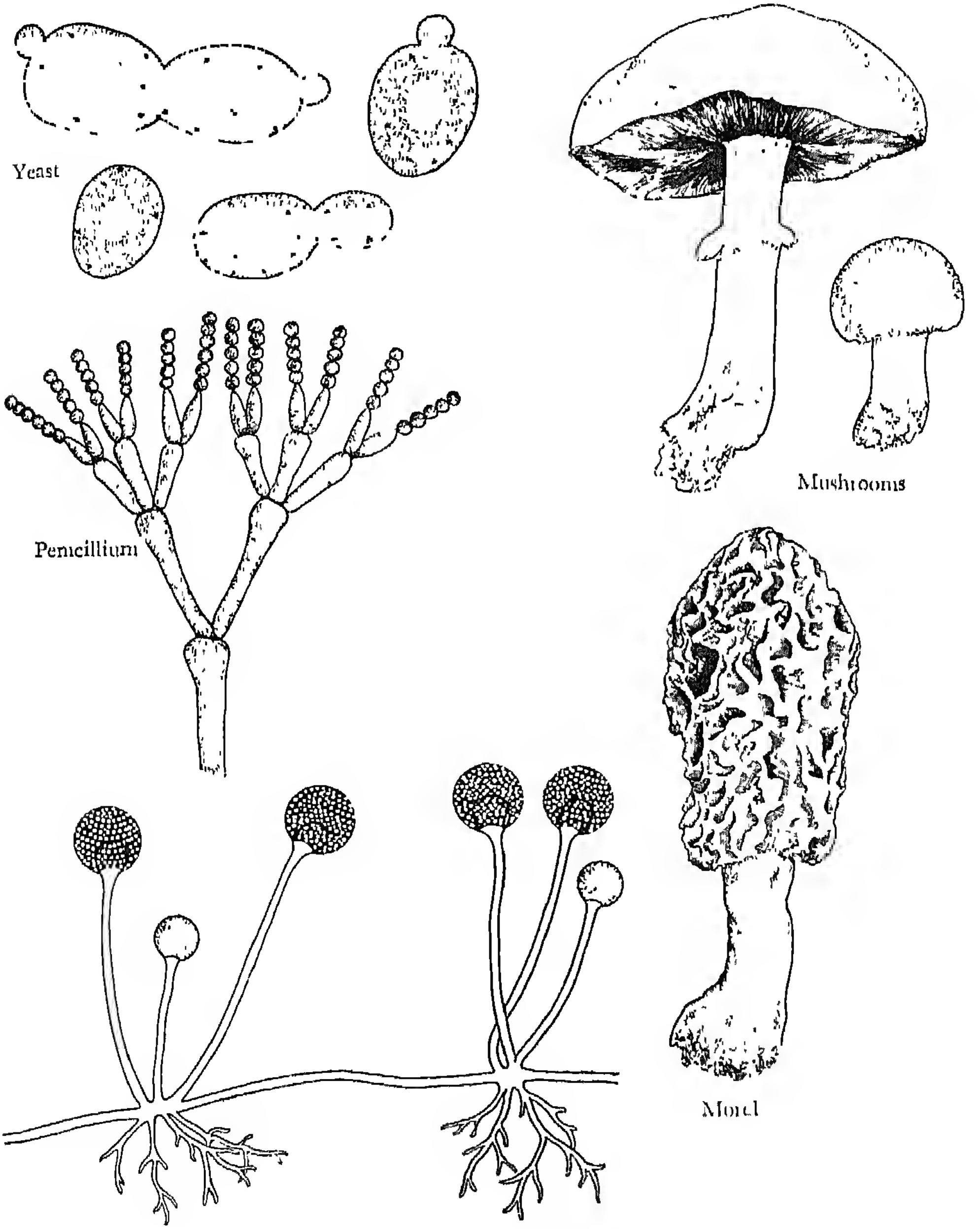

Fig. 1. Some Fungi

Apart from their direct utilization as articles of food, the fungi also support several food industries. The baker uses yeast as 'leaven' to make his bread, cakes and pastries rise. Several varieties of cheese like 'Camembert', 'Rocquefort' etc., owe their fine flavour, texture and distinctive 'marbling' to the growth of mould, mostly species of *Penicillium* or *Aspergillus*. 'Food Yeast', usually marketed in the form of pills or small cakes is particularly rich in vitamins and is used as a food supplement to prevent or cure deficiency diseases. It is the product of the yeast *Torulopsis utilis*, a fungus closely related to the bakers' and brewers' yeasts.

However, all the activities of fungi are not beneficial to mankind. The parastic fungi exert considerable pressure on human economy as the causal agents of plant, human and animal diseases. Even the saprophytic fungi, whose activities in the main are beneficial are responsible for great damage, particularly in the tropics, where they cause widespread destruction of food, timber, fabrics, leather and all other goods made of material easily susceptible to their attack.

Plant diseases vie with plagues of insect pests and unfavourable weather for pride of place as the greatest hazard in man's continual struggle to feed and clothe himself. Food-deficient countries must aim at maximum production; countries with surpluses must try to adjust production.

A sudden and widespread outbreak of plant diseases constitutes a great handicap, which man must have felt almost as soon as he started cultivating plants for food or clothing. Reference to losses caused by plant diseases '...due to pestilence, blasting and mildew...' is found in the Bible. The writings of Theophrastus and Pliny show us that from about 700 B.C. fungal plant diseases were recognized as the 'greatest pest of crops'. The Romans believed wheat rust was due to the anger of the god Robigus and held annual ceremonies in propitiation. Plant diseases caused by fungi have continued their destructive careers through the centuries and still constitute a serious menace to crops all over the world. The potato famine in Ireland in 1845 which caused widespread misery resulting in the death of over a million persons and the emigration of more than a million and a half others, was due to the late blight disease of potatoes which broke out on a large scale. This had also an important historical repercussion in that it led to the repeal of the corn laws. Outbreaks of 'downy mildew' in the French vineyards resulted in severe setbacks to the wine industry of that country. 'Chestnut blight' affected the timber industry in the United States to a very large extent. In our own country, as elsewhere, fungal diseases like rusts and smuts of wheat and barley, smut and red rot of sugar cane, blast and leaf spot of rice, and others result in substantial losses year after year. Plant diseases may be annihilating, limiting, devastating, debilitating or disfiguring and might destroy standing crops, eliminate crops from certain areas, force substitution of low value crops for high value ones, weaken crop plants and reduce yield or disfigure and thereby reduce the market value of plant products. In addition to the actual damage they cause, plant diseases also levy a tax on the farmer and grower in the cost of preventive and control measures or by the limitations imposed on the kinds and varieties of crop plants which can be grown in particular areas.

It would be impossible to give accurate figures of financial losses due to plant diseases in all important agricultural countries, but undoubtedly it must run into billions annually Plant diseases are very important factors in decreased food production and the concomitant increase in cost of food This is a critical problem in those countries where there are shortages and can become ruinous in an increasingly populous world In the present context of explosive rates of population increase all over the world, plant diseases caused by fungi and their control are bound to be vital factors in any nation's economy.

The fungi also cause several diseases in man and animals. These are collectively termed 'mycoses' by the specialist They may be superficial skin infections like 'ringworm', 'dhobies' itch', 'barber's itch' or 'eczema', or more deepseated infections like 'Madura Foot'. Some fungi are also responsible for systemic or chronic infections like 'Histoplasmosis' which may sometimes even be fatal. Cattle, poultry and even household pets often develop mycoses due to infection by various species of these fungi. The very air that all of us breathe often carries a heavy load of fungal spores resulting in various kinds of allergies like hay fever and asthma.

To sum up, therefore, the activities of the fungi are in many ways intimately linked with human welfare and economy and, as said before, there is perhaps scarcely a day during which we are not harmed or benefitted, directly or indirectly, by these organisms. In future too, the various activities of the fungi are bound to extend into ever-increasing fruitful or harmful fields as yet unknown. As an eminent mycologist has recently stressed, whether we continue in our successful utilization of their potentialities or whether we fail and ourselves perish, depends on us, not the fungi.

Vitamin Content of Eggs

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THE avian eggs are good storehouse of vitamins and probably they are the only food material where most of the vitamins are present in very good amounts. As eggs supply all food materials to the developing embryos, it is naturally expected that all macro- and micro-nutrients must be present in eggs. The vitamin content of eggs is quite variable depending on a number of factors, such as breed of birds, nature of poultry diets, season of the year, and health and environmental conditions. Of the ingested vitamins present in the diets a part is utilized by birds to maintain various physiological processes and the rest is stored in liver and muscles. During the time of egg-laying the liver's store of these excess vitamins are drawn upon for deposition in eggs. Hence by feeding birds with vitamin-rich diets the vitamin content of eggs can be suitably raised to the benefit of consumers. The distribution of various vitamins in eggs is generally influenced by their solubilities. The fat-soluble vitamins are concentrated in the yolk which contains all the fats of the egg. The water-soluble vitamins occur in both yolk and albumen.

Vitamin A

Vitamin A keeps eyes bright, skin smooth and promotes growth. This vitamin is present in the egg to the extent of about 60 International Units. Because of its vitamin A content the egg cures xerophthalmia and improves growth. As it is a fat-soluble vitamin it is exclusively present in the yolk. The yolk is a better source of vitamin A than any other natural food of animal origin except liver and butter fat. Some precursors of vitamin A, which are converted in the body into vitamin A, are also present in the egg yolk. Grasses, alfalfa, and yellow maize often fed to laying birds provide large amounts of carotenoid pigments including a good amount of vitamin A precursors. A diet rich in these substances fed to laying poultry leads to production of eggs containing considerable quantities of actual vitamin and its precursors. Hence it is commonly believed that highly pigmented yolk is rich in vitamin A. The summer eggs contain more vitamin A than the winter eggs. Moreover, the first eggs of laying seasons are richer in vitamin A than those laid at the close. Though the vitamin A content of the egg is variable, three to five eggs a day are sufficient to meet the human requirement of vitamin A, if eggs are the sole source of this vitamin. Vitamin A is fairly heat-stable at 100°C and is more readily destroyed by oxidation and sunlight than by heat. A partial loss of vitamin A occurs when eggs are cooked. Cooking for 7–10 minutes perhaps destroys as much as 40 per cent of this vitamin.

Vitamin D

Vitamin D ensures sturdy bones and good teeth and prevents rickets. This vitamin is present in the yolk of the egg to the extent of about 40 International Units, and hence eggs cure rickets in infants with beneficial effects on calcification. In fact, the egg is second only to fish oils as a source of vitamin D. The variation of vitamin D content of eggs is believed to be due chiefly to the variation in the amount of direct sunshine hens receive and the level of vitamin D in the poultry ration. Exposing hens to artificial ultraviolet light is a fairly good practical means of raising the vitamin D content of the egg and sometimes ten-fold increase in anti-rachitic activity of hen's egg is thus obtained. The summer eggs are more than four times as rich in vitamin D as the winter eggs. The cooked egg is probably equally as valuable a source of this vitamin as the raw egg. Boiling for 20 minutes destroys little or none of the vitamin. One egg in the diet contributes about 15 per cent of the daily requirement of this vitamin for a growing child or a normal adult.

Vitamin E

Vitamin E is said to be essential for normal reproduction in men and animals. Eggs are found to ensure good reproduction. The egg's vitamin E content is about 430 microgrammes.

Vitamin K

Antihemorrhagic vitamin K or menadione is essential for proper formation of prothrombin and hence for normal blood-clotting. In the egg, vitamin K amounting to about 42 microgrammes per egg is mainly concentrated in the yolk. Hard-boiled yolk gives protection to chicks suffering from vitamin K-deficiency, but the albumen does not. Like all other vitamins its content in the eggs is variable depending upon the level of this vitamin in the hen's diet. The eggs laid in late winter and in early spring contain less vitamin K.

Thiamine

Vitamin B_1 or thiamine prevents polyneuritis, promotes strong nerves and tones heart muscles. The hen's egg's entire content of thiamine is concentrated in the yolk and the albumen has no antineuritic properties. The average thiamine content of the yolk is 90 microgrammes. Eggs laid by birds on thiamine-rich rations are two to three times richer in this vitamin than eggs of birds on thiamine-poor diets. White Leghorns lay eggs containing considerably more thiamine than those of Rhode Island Reds or Barred Plymouth Rocks. This vitamin is somewhat heat-labile, except in acid solution. Cooking reduces slightly the egg's content of this vitamin. Storage at low temperature over a month does not appear to reduce thiamine content of the eggs. An average egg provides approximately 5 per cent of the daily requirement of this vitamin of an adult man.

Riboflavin

Vitamin B_2 or riboflavin is essential for a healthy mouth and prevents dermatitis. Riboflavin is present in both yolk and albumen. The average concentration of riboflavin in the yolk is 80 microgrammes while albumen contains about 125 microgrammes. Although riboflavin is destroyed by light, it is heat-stable. The activity of this vitamin is retained in cooked eggs.

Biotin

In the hen's egg there are 8.5 microgrammes of physiologically active biotin present in the yolk. Albumen contains about one-fourth of this amount and biotin, in combination with avidin protein of the albumen, remains entirely inactive there. When the egg is cooked biotin is released from the avidin-biotin complex Raw albumen contains avidin in sufficient excess to inactivate the biotin of the entire uncooked egg and of other food materials. The egg white injury characterised by an eczematous dermatitis accompanied by denudation, muscle pain, loss of weight and some nervous disorders may occur due to regular intake of raw fresh egg albumen. Albumen coagulated at 65°C is less toxic than raw egg white. The toxic properties disappear completely when albumen is heated at a temperature of 80°C for 5 minutes.

Other Vitamins

Inositol promotes healthy skin and hair. In the egg its concentration is high and the average value is about 12 mg per egg.

Pyridoxine promotes muscular relaxation and the egg is a fairly good source of pyridoxine. The average egg contains about 125 microgrammes of pyridoxine which is nearly equally distributed in yolk and albumen

Folic acid protects against anaemia but eggs are poor source of this vitamin, since each egg does not contain more than 5 microgrammes of this vitamin. Similarly vitamin C or ascorbic acid which increases resistance to infection and prevents scurvy is present in eggs in very minute amount.

Niacin promotes digestion, ensures strong nerves and healthy skin However, niacin content of the egg is about 31 microgrammes present mostly in the albumen. Hence an egg supplies a very small percentage of the adult man's daily need. Niacin of eggs is stable and not destroyed much during either cooking or spray drying.

Pantothenic acid forms a part of coenzyme A, an important compound of the body. The whole egg contains about 610 microgrammes of pantothenic acid mostly in the yolk. Its content in eggs can be easily raised by feeding hen pantothenic acid-rich diets. This vitamin appears to be heat-stable.

The hen's egg contains about 250 microgrammes of choline present mostly in the yolk and it is, therefore, one of the richest known source of this vitamin. It is contained in lecithin, an essential phospholipid of the body.

Vitamin B_{12} is an anti-anaemia vitamin. Its content is about 390 millimicrogrammes present mostly in the yolk.

The egg is a highly concentrated food because of its great variety of nutritive substances. When consumed, the egg aids in maintaining health of normal adult, in promoting growth and development of children and in restoring the depleted body reserves of the convalescent. In the treatment of various disorders due to deficiencies particularly of vitamins and minerals the egg is an essential diet.

How Hybridization Helps

G. W. Erion
The Rockefeller Foundation, New Delhi

THE work to make hybrid maize seed and other hybrid seed for farm and gardens is an outstanding achievement in the application of the science of genetics to agriculture. This development has changed the agricultural economy of progressive countries all over the world.

Hybridization of maize enables the cultivator to obtain seed of a type which shows extra vigour and gives more production over either of the parents.

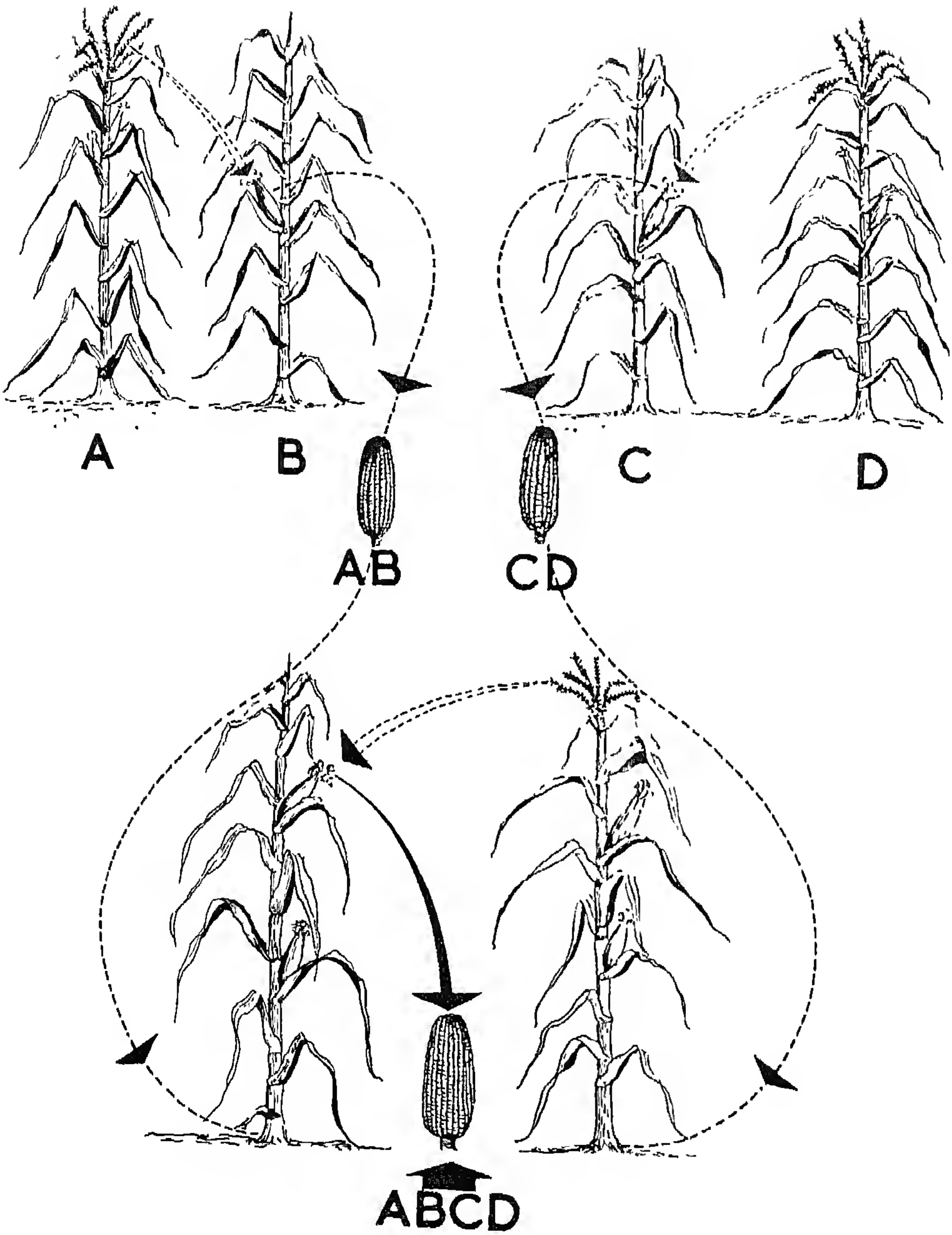
The unique system of producing seed on only a portion of the maize plants grown in a field requires an entirely different concept in seed production. The inbreds must be grown in sib isolations 200 metres or more from any other maize, the greater the distance the better. The single-crosses also must be produced in isolated fields, a distance of 200 metres from other maize. The planting ratio in single-cross isolations is two rows of male to four rows of seed parent. Then the double-cross fields must be isolated. The isolation may be reduced if additional border rows of the pollinator parent are used according to the Seed Certification Standards

Certified Seed is said to be the start of a big yield. Using your own hybrid maize seed will result in a poor yield, because the hybrid vigour is lost after the double-cross. In order that the maize farmers get really high yielding maize seeds, the production programme is being checked. There are inspections in the seed production fields and in the seed processing plants, also germination tests by trained seed analysts in official seed testing laboratories

You may know that the only hybrid seed available is produced anew each year by detasseling one of two single-crosses. The production of hybrid maize varieties has been one of the most notable developments of the 20th century, and the plant breeders are busy developing new hybrids all the time.

Hybrid maize has the ability to outyield local varieties Adequate fertilizers when applied will increase yields of the local varieties as well as the hybrids but the hybrid maize has the ability to yield two to several times the amount of the *desi*

The hybrid maize can be used as poultry and livestock feed. In areas where maize is grown, it is generally taken as food by the people. It is also used in textile and chemical industries. Hybridization is used not only with maize but in also other crops to increase quality and yield.



Double Cross—Hybrid corn

Exploring the Indian Ocean*

N.K.Panikkar

Director, Indian Programme of the International Indian Ocean Expedition, New Delhi

[The International Indian Ocean Expedition is a great co-operative endeavour in which about twenty countries have provided more than 40 vessels to cruise the different parts of the Indian Ocean. The research conducted by the Expedition is designed to 'observe, describe and possibly explain the circulations of ocean and atmosphere and exchanges across their interface as well as the chemical composition and distribution of the living organisms in the ocean and the bottom topography and coastal structure' of its largely unexplored ocean which constitutes one-seventh of the earth's surface. There are reasons to believe that gigantic deposits of oil, natural gas and almost all kinds of minerals lie beneath the ocean floor which could be added to the world's supply. The programme was first discussed and organized by the special committee on Oceanic Research of the International Council of Scientific Unions. The project found support from the national academies and scientific institutions of many countries. These countries include Australia, East Africa, France, Germany, India, Indonesia, Japan, Pakistan, Portugal, South Africa, the U.K., the U.S.A and Russia. Each country bordering the Indian Ocean had provided shore stations and personnel for local observations.

India has a special interest in this Expedition because of her geographical location. The Government of India set up the Indian National Committee on Oceanic Research in 1960 under the Chairmanship of Dr. D.N. Wadia. Indian participation in the International Indian Ocean Expedition includes a programme of investigation which will cover most aspects of modern oceanography which could be accomplished from the few vessels, earmarked for this work and with the equipment and trained personnel available in India for Oceanographic Research.

The expedition will provide basic information relating to the Indian Ocean and indicate the material resources which could be exploited. Knowledge of ocean currents will be of benefit by reducing cost of oceanic transportation. Coastal work would throw light on problems of coastal erosion and sedimentation. The Meteorological Centre at Bombay will help improvement in weather forecast services and a better understanding of monsoons which have a large economic impact on the development of agriculture, irrigation, etc. The Biological Centre at Cochin will help in obtaining a complete picture of plant and animal life in the Indian Ocean. All these activities will act as a great stimulus to scientific research and development in the field of marine science in the country.

Many Indian scientists are participating in the Indian programme of the International Expedition and we reproduce below an article by Dr. N K.Panikkar, Director of the Indian Programme of the International Indian Ocean Expedition. —EDITOR]

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WELL over seventy per cent of the earth's surface is covered by the oceans. Yet it is strange that we know so little of what is beyond the surface and the marginal seas. The sea has played a great part in the history of nations, their economic development and the dissemination of cultures and civilizations from the dawn of history. It has been a great link between distant lands, but at the same time it has been an effective barrier between countries and continents. Man's conquest of the sea through progressive development of water-transport is a story by itself, but equally fascinating is the way in which the secrets of the ocean have been discovered through tireless efforts of marine scientists during the last hundred years. A renewed awakening in studies of the 'inner space', more conventionally called oceanography, is now taking place all over the world with more scientific effort and ships directed to oceanic exploration

Scientists interested in ocean studies met at the First International Oceanographic Congress, held in New York in 1959, which witnessed the emergence of this branch of human knowledge as an international science. They then had an opportunity to exchange thoughts on the paucity of information relating to the Indian Ocean whose further exploration has been suggested by the Special Committee on Oceanic Research at their earlier meetings The project took a more precise shape during the New York meeting: several working groups were formed which developed the programmes under various disciplines to be pursued during the Expedition. At the present time Indian Ocean is receiving more scientific attention than has been given to any other part of the world oceans at any previous time It has blazed new trails in international science following the valuable gains obtained in a similar co-operative scientific endeavour, the International Geo-physical Year, launched during 1957.

Multi-National Effort

With about twenty countries expected to take part and with nearly forty ships cruising the different sectors of the Indian Ocean, the Expedition started in 1962 will go on through 1965. In this major venture in oceanographic researches well over five hundred scientists from all parts of the world are collaborating. The peak period of activity is 1963-65. Now is the time when preliminary results obtained during the earlier cruises are being utilized to frame more critical and detailed programmes of investigations to be attempted in the following years. The principal persons connected with the project will meet shortly at the UNESCO Headquarters in Paris, to exchange notes, review the progress made so far and formulate a system of exchange of scientific data collected by various groups in an effort to build up an integrated knowledge of the Indian Ocean

Why the Indian Ocean ?

It is often asked: why is it that the Indian Ocean has been particularly chosen for such detailed studies? Apart from its being less known than the others, the Indian Ocean has several features of great scientific interest. It is the only major ocean which is landlocked on the north and is not connected to either North or South Pole like the Pacific or the Atlantic. The system of oceanic circulation is thus substantially different. The differential heating of the land and water

masses in the northern Indian Ocean has been the probable cause of violent atmospheric circulations manifested in the monsoons and tropical cyclones. The change in the monsoons witnesses the complete reversal of the direction of wind and currents twice during the year in many parts of the Indian Ocean. It is often said that the Arabian Sea which is more subjected to the influence of the monsoons than probably any other part of the Indian Ocean is a unique field-laboratory for the study of atmospheric and oceanic circulations, where many theories could be tested by field observations.

Theories apart, monsoons have a great influence on the economy of the countries around, and an accurate knowledge of their formation, onset and duration are of the highest value. Nearly one-fourth of the human race lives in countries bordering the Indian Ocean in a low degree of economic development and often in perpetual under-nourishment. In the exploration of this oceanic region, we have the economic incentive of looking for untapped fisheries and mineral resources. The fisheries which are usually considered poor in the tropical waters, which are not replenished by natural circulation as it prevails in the temperate latitudes, might still be found in great abundance in regions subjected to up-welling of the nutrient-laden waters from below. Such fishery resources as yet unutilized may well exist in certain areas of the Indian Ocean. The continental shelves which adjoin many countries are quite wide and economically capable of exploitation; they may form areas of useful mineral wealth and even petroleum. Apart from these, oceanic studies by themselves might bring to light new raw materials and sources of energy capable of development and utilization.

Some knowledge of the geology of the Atlantic and the Pacific has been gained during recent years. Very little is known of the Indian Ocean regions. Even the simple bathymetric charts indicating bottom topography are woefully incomplete. The difference in the crustal composition of the ocean floor of the Atlantic and that of the Pacific is now established and explained on the basis of the postulate that the moon has separated off from the earth at the region where we now have the Pacific. The land-masses which at one time in the geological past remained connected, have crumbled, broken and drifted, the boundary relations of the geological floor with the land, submerged lands and islands, and the composition of ocean deposits and sediments, are some of the means of reconstructing the past history. Geological and geophysical techniques developed during recent years have opened many new methods of study of the ocean floor-complex, which will be applied to the Indian Ocean investigations.

The Programme

The Indian programme for the Expedition has been prepared by the Indian National Committee for Oceanic Research. Attempts will be made to begin work in all the major disciplines of oceanography. This is a young science in India. Our resources in ships and personnel are necessarily limited. Modern oceanography involves the use of well-equipped ships, advanced instrumentation and highly trained personnel. A sea-faring tradition, a well-established navy, and a prosperous merchant naval and fishing fleet have enabled other countries

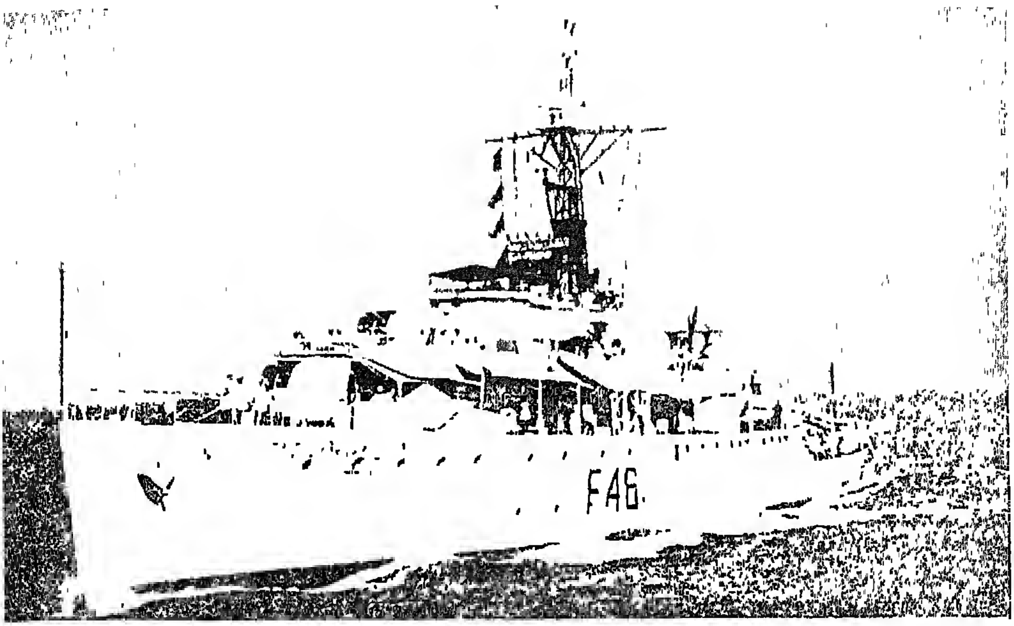
to work in this field with greater facility and support. In all these fields we have yet to go far. Not enough men from Indian universities having adequate basic training in the related sciences are readily available to take to the arduous work on the ships But these difficulties are being fast overcome. The stimulus given by the International Indian Ocean Expedition and the activities of the Indian National Committee for Oceanic Research have enabled the country to frame programmes of Indian participation commensurate with our needs. The naval frigate, *INS Kistna* which was being used as a training ship, has been commissioned for the Expedition and specially equipped for oceanography of distant waters. The fisheries research vessel *RV Varuna*, operated by the Indo-Norwegian Project and equipped for fisheries oceanography, will be used specially to study coastal waters. A number of fellowships in oceanography have been awarded by the Government of India and the Council of Scientific and Industrial Research Quite a few special fellowships have been secured for training Indian scientists in special disciplines at research institutes in advanced countries and also in the research vessels belonging to the USA, the UK and the USSR. Two persons have received special training in instrumentation techniques Most of the experienced personnel working on problems connected with oceanography in Defence, Fisheries and University organizations have been co-operating in the execution of the Indian programme with equipment newly acquired by various organizations with the help of the Indian National Committee and also with that provided generously by the UNESCO.

The first scientific cruise of *INS Kistna* was inaugurated in October 1962 by Prof. Humayun Kabir, the then Union Minister for Scientific Research and Cultural Affairs, and since then she has completed 15 cruises covering well over 300 stations in the Arabian Sea, the Bay of Bengal and northern Indian Ocean up to the Equator The Indo-Norwegian Project Vessel, *Varuna*, has in 1962-63 covered nearly 400 stations, mainly in the western coastal areas Indian vessels with the experience of earlier cruises and improved equipment will pursue the programme during 1964 and 1965. While to other countries the Expedition is something which will taper off by 1965, to India the Expedition is a continuing national activity, the location of the country in the Indian Ocean making India's destiny inseparable from the happenings of the seas that wash her shores.

Interesting Findings

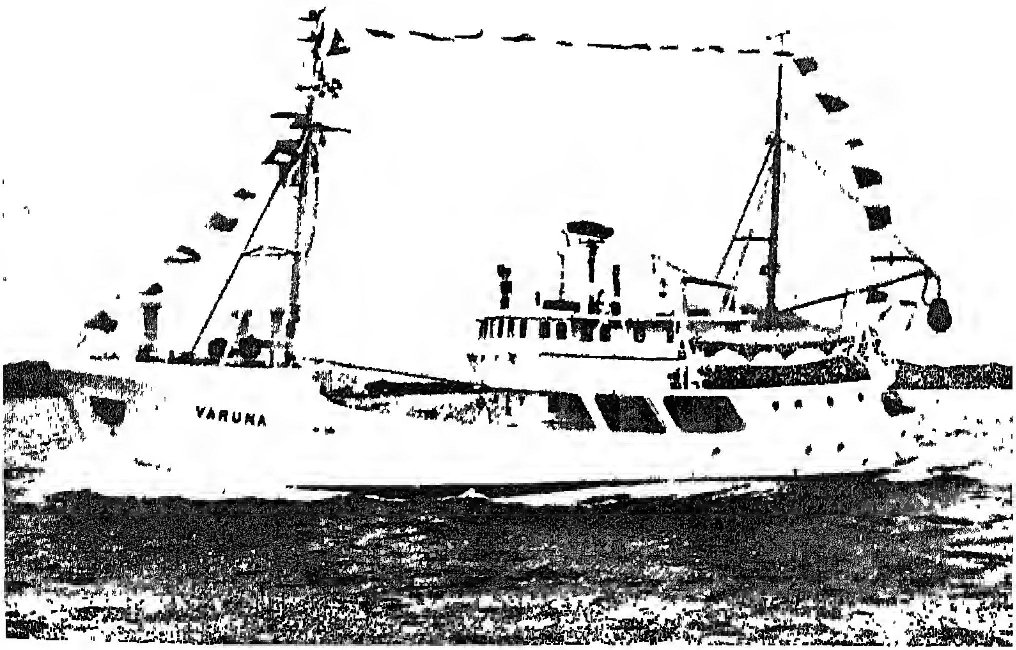
Some of the results obtained by the participating ships are as follows. (these should not be taken as final results but only as indicating current thinking on some of the problems under investigation).

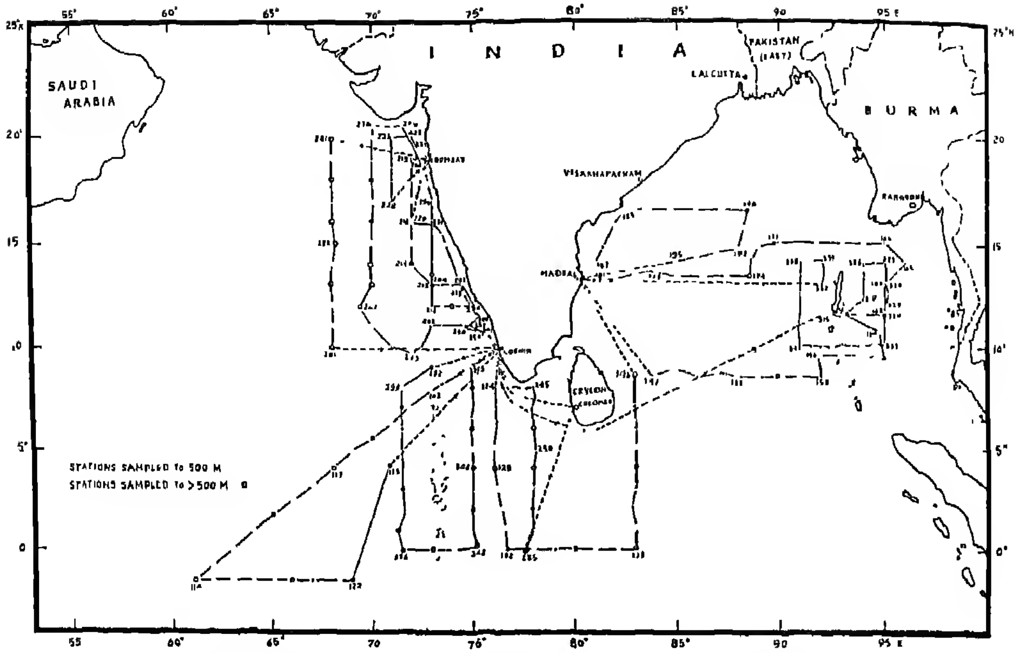
US VESSELS. The two United States Research Vessels—*Argo* and *Horizon*—made extensive geological studies of the ocean floor during 1962. They were concerned also with problems of oceanic currents. The need for this has arisen from an important discovery made some years ago of the existence of a strong equatorial under-current in the Pacific below the surface at considerable depth, running eastwards counter to the surface current. This current, called the Cromwell Current after its discoverer, has been demonstrated in both the Atlantic and the Pacific. Is the development of such a



INS KISTNA: A frigate of the Indian Navy fitted for oceanographic work for the Expedition period.

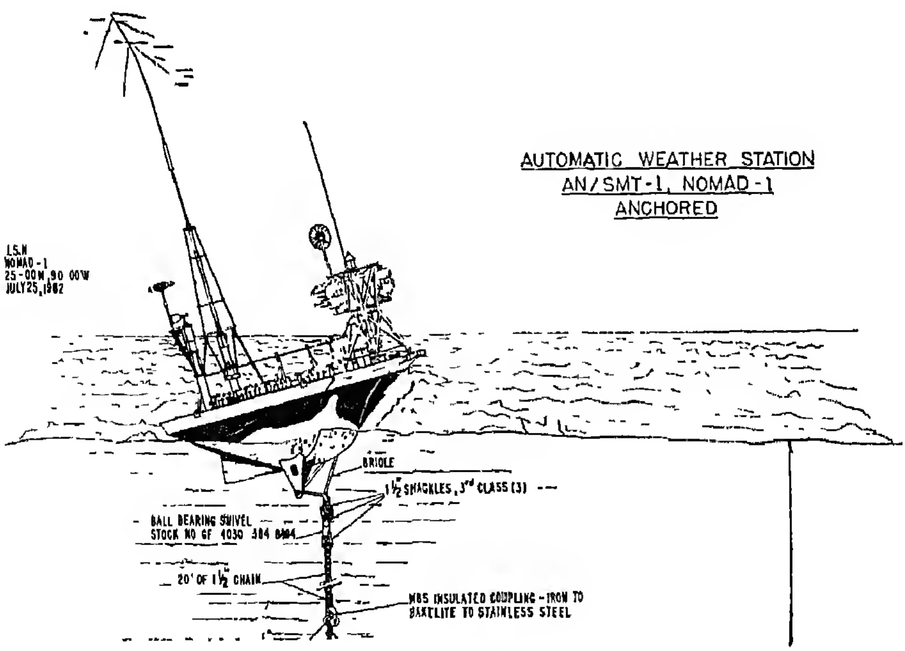
R.V. VARUNA: Oceanographic Research Vessel of the Indo-Norwegian Fisheries Project, Kerala.





Cruise track and station positions of INS Kistna during 1963

Autematic Weather Buoy NOMAD



circulation possible in a partially closed system like the Indian Ocean? The observations are that if such a current exists at all, it is not so pronounced, nor of such magnitude as in the Pacific or the Atlantic.

The United States Programme has received impetus with the recent arrival of the research ship, *Anton Bruun*, in Bombay in March 1963 and her first cruise started on the Bay of Bengal coast from Puket (Thailand). She did a series of stations between the Andaman Sea, the northern part of the Bay of Bengal, Visakhapatnam and Madras The findings of interest are that, as judged from the amount of fertilizing substances brought to the surface of the ocean, the Andaman Sea and the head of the Bay of Bengal are rich in fish and could probably support considerable fisheries, while the rest of the Bay does not appear to be so productive. More areas remain to be explored and at other seasons as well. India has great interest in finding new fishing grounds because the present production of sea fish in the Bay of Bengal is only about one-fourth of the total Indian sea-fish production. Another finding of interest by *Anton Bruun* as seen from the profiles of the sea floor taken by precision depth recorders is that, as one approaches Visakhapatnam from the northern side of the Bay of Bengal, there are three deep canyons of about 1300-1500 metres depth. These depressions into the sea have not been reported before. One of the geophysical findings from *Argo* is the difference in the east-west pressure gradient in the Indian Ocean. In the Pacific and the Atlantic there is a tilt towards the east, i.e., the sea surface slopes down towards the east along the equator. A gradient of the same magnitude has been observed in the Indian Ocean, but the tilt is exactly in the reverse direction, i e, westward Is this tilt constant or variable according to seasons? In June-September there is no evidence that the direction of gradient changes, but data for the other seasons have yet to be obtained. All these point to the need for more study. Another ship, *Atlantis*, is now on cruise of the southern part, more US ships are expected to visit India in 1964 and 1965.

SOVIET VESSELS: The Soviet research ship, *Vityaz*, had done some cruising of the Indian Ocean in 1960-61 and has accomplished more detailed work for the expedition in 1962 This ship has a very comprehensive programme covering physical, biological, geological, chemical and geophysical aspects of research and, being a large ship, she is able to take about 50 to 60 scientists at a time. The detailed findings of *Vityaz* have not come out as yet, but they have indicated the existence of large patches of oxygen-free water at considerable depths in the Arabian Sea and the Bay of Bengal. The oxygen-free water, of course, means that there is no plant or animal life in it and often these areas are charged with considerable quantities of hydrogen sulphide. What are the reasons for the formation of such barren areas in definite pockets of the Indian Ocean ? This has to be reviewed against the findings of similar zones south of Arabia by the John Murray Expedition early in the thirties. Only further work can answer some of these problems, but some scientists have not been slow to speculate that at least some of them have a bearing on the complex process of formation of oil deposits. The Soviet ship also

collected nodules of manganese from great depths and it is a matter of mystery how these are formed in the depths of the ocean.

UK PROGRAMME: The main part of the United Kingdom programme in biology started this year with their new ship *RRS Discovery* which is now working in the Arabian Sea, but some work of great interest to geology and geophysics was done in 1962 by *HMS Owen*. These relate to the geological formation of the sea-bed between East Africa and India where existed the Gondwanaland which had in the geological past sunk into the ocean. It is probably too early to discuss these results, but the trends of researches indicate that some of the older concepts may require revision, particularly the mode of formation of the island groups, Seychelles and Mauritius.

CRUISE OF KISTNA: The Indian work during 1962 and 1963 has been mainly in the field of physical and biological oceanography and meteorology. *INS Kistna* went round a very large number of stations in the Arabian Sea right up to Socotra towards the west and to the equator in the south. She did also a number of stations in the southern part of the Bay of Bengal. A clear picture of the composition of water masses in these areas is now emerging and some of the first observations on upper air soundings in the Arabian Sea by radiosonde have been done from this ship by the Indian Meteorological Department. Indian weather predictions are now based on overland data although weather is largely influenced by happenings in and above the sea. Maritime observations are augmenting South Asian meteorological work for the first time. To develop this on a firm footing an International Meteorological Centre has been established in Bombay with United Nations assistance for the specific purpose of studying the large volume of atmospheric data that would be collected from various ships participating in this Expedition.

CRUISE OF VARUNA: The second Indian ship, *RV Varuna*, has done valuable work particularly on the problem of upwelling and fisheries of the south-west coast. It is not often realized that, like the land, the sea has also fertile and barren areas. One such extremely fertile area is that part of the Arabian Sea near the south-west coast of India where the main fisheries for sardines and mackerel exist. Their abundance is connected with the oceanography of that region, i.e., on the sequence of events leading to the fertilizing substances being brought to the surface by upwelling, which means that waters from the depths of the ocean force them upwards and they come to the surface. The full story of this upwelling has not been understood, but from the study of results obtained by the *Varuna*, we are getting an insight into this complex process. Waters of low oxygen and low temperature from the deeper parts of the ocean rise towards the surface, between Mangalore and the Cape Comorin. This upwelled water may not always come to the surface, although it does break through here and there. It gives rise to a burst of dense growth of plant and animal life, called 'plankton', on which fishes subsist. The relation of upwelling to the current systems, the monsoon winds and other factors, are now being studied.

The cruises of the *Varuna* have also helped us to locate deep water patches of

sardines and mackerel which have been found only in surface waters before. A large scale effort will be made during the Expedition for finding fertile marine regions through the study of the density of the plankton in different regions and seasons at various depths. A specially designed net, the Indian Ocean Standard Net, is being used for collecting the plankton by all the ships participating in the Expedition, and these collections are brought to Ernakulam (Cochin) where an Indian Ocean Biological Centre has been established by the Council of Scientific and Industrial Research with UNESCO assistance to study several hundreds of samples.

Exploring the ocean is a slow and arduous pursuit. Often the results are not spectacular, with little popular appeal. But every scrap of information on any aspect of the wide ocean helps in the long run. Thus is built up the true picture of this vast storehouse of life and energy, on whose bounties live millions of peoples and whose resources hold out great promise to mankind in the incessant march of man for mastery over nature.

Central Food Technological Research Institute, Mysore

THE Central Food Technological Research Institute is housed in the palatial Cheluvamba Mansion which was received by our late Prime Minister, Shri Jawaharlal Nehru, from the Government of Mysore on December 29, 1948. The Institute was formally declared open by Shri C. Rajagopalachari on October 21, 1950. In addition to the Mansion, the Institute has today two equally big buildings, *viz.*, the Processing Wing and the Technology Block on the south and north of the main building respectively, and two more separate buildings which are intended to house the Meat and Fish Technology Division, and Infestation Control and Pesticides Division are under construction.

The main objectives of the Institute are

1 To prevent incidence of heavy losses of foodgrains and perishable foods which take away a heavy toll at present.

2 To assist the food processing industries in their development programmes.

3. To develop new processes and products based on indigenous raw materials and at prices within the easy reach of the common man

4. To undertake long range research and development programmes in the fields of food science and technology.

The initial annual budget of the Institute which was about Rs. 4 lakhs, has now increased to about Rs. 36 lakhs, and it is expected that by the end of the Fourth Plan, this will be further doubled The staff of the Institute number 750 including scientists, technologists, engineers, administrators, and other auxiliary staff

The research and development programmes of the Institute have recently been organized under the following disciplines:

1 Fruit and vegetable technology
2. Meat, poultry and fish technology
3. Cereal and protein food technology
4 Spices and flavouring technology
5. Fermentation technology
6. Infestation control and pesticides
7 Biochemistry and nutrition
8 Food engineering and process development.
9. Industrial research and consultancy services.
10. Regional experiment stations
11. Advanced and refresher training programmes.
12 Information and extension services.

The whole programme in the above disciplines of the laboratory is being carefully studied to bring it on the project-oriented approach, and formulation of research projects on clearly identified problems which will have time targets, scheduled budgets, and pre-determined team of personnel.

The Institute has made a tremendous impact on the industry by providing solutions to several problems, and through the development of new processes and products. Out of these, a few which represent the outstanding accomplishments are here described.

By courtesy of the Director, Central Food Technological Research Institute, Mysore.

A general view of the workshop where equipment is fabricated

Baby Food from Buffalo Milk

As a result of the investigations carried out at this Institute, a process has been developed by which it has become possible to manufacture infant food from buffalo's milk. This comprises standardization of the fat content of buffalo's milk by partial skimming, addition of buffer salts and sugars, fortification with vitamins followed by homogenization and drum/spray drying. The product compares favourably well with some of the most popular infant foods produced in different countries of the world. This process has been accepted by the Kaira District Co-operative Milk Producers' Union, Anand, who are marketing the product under the name 'Amul Baby Food'. This finding has resulted in saving a large amount of foreign exchange, besides developing an indigenous industry to meet the growing needs of the country.

Edible Quality Groundnut Flour

The major deficiency in the dietary pattern of the Indian population, particularly of the vegetarian group, and still more so of young children, is that of protein. While the minimum protein requirement prescribed by international organizations is 65 grammes per person per day, an average Indian barely gets 40 grammes per day. The deficiency could be overcome expeditiously and adequately by the utilization of the available protein sources (obviously in the vegetable kingdom) in the country. Groundnuts which are produced to the extent of four million tons every year have been used only as a source of oil, the meal fraction, because of its inedible quality, being used for cattle feed and manuring. A process has been developed by which edible quality, low-fat groundnut meal, which has about 50

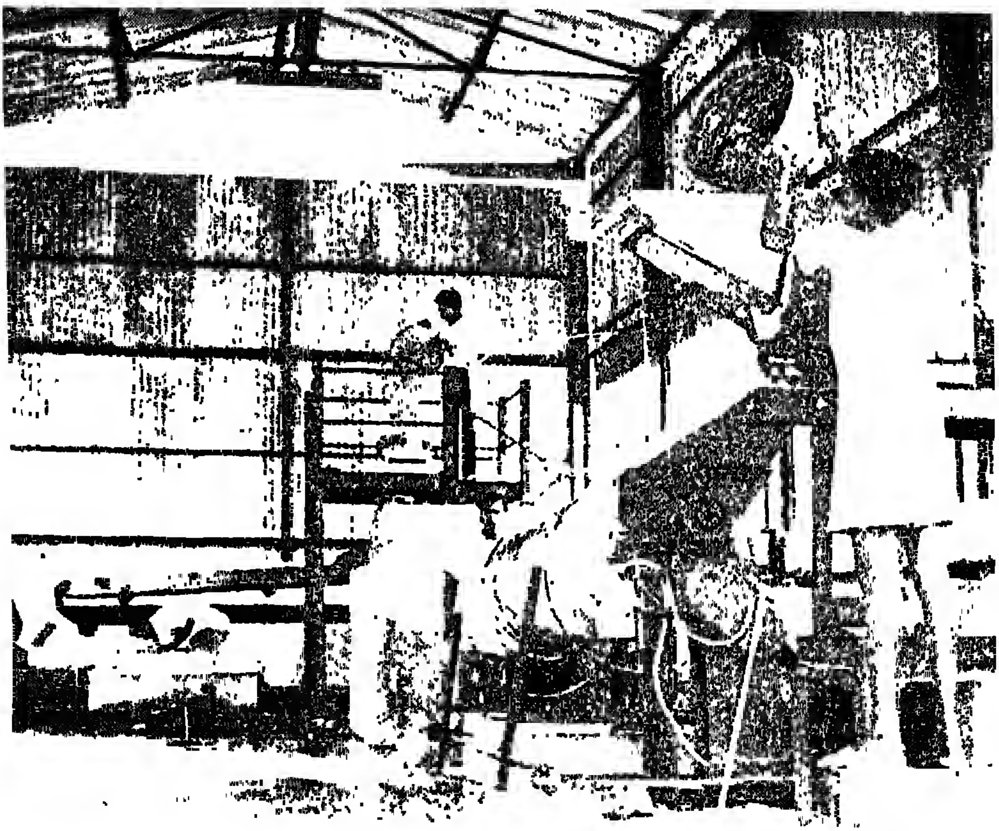
per cent protein, has been prepared. The total production of groundnut would yield about one million tons of the protein. The development of this product has created both national and international interest. The UNICEF has donated two plants with a capacity of ten tons each for the manufacture of groundnut flour, while several State Governments as also the Central Government are enthusiastically following up this programme under the technical advice of this Institute.

Indian Multipurpose Food

This is a cheap protein-rich product prepared from indigenous and easily available raw materials, *viz.*, three parts of groundnut flour and one part of Bengal gram flour, the blend having a full complement of added vitamins and minerals. The product is very versatile and lends itself to many uses in the dietary of the people without necessitating any major change in their food habits A person can overcome the deficiency of protein, minerals and vitamins in his daily diet by incorporating 25–50 gm. of Indian multipurpose food at a cost of about 6 paise.

Groundnut Protein Isolate

This is 95 per cent pure protein prepared from groundnuts according to a technique developed at this Institute. The process has been leased to Messrs. Tata Oil Mills Company, Limited,



Pilot plant for the recovery of pectin in the integrated process

Bombay. A considerable portion of the equipment for this process has been designed and fabricated at this Institute, while some other essential parts have been imported The plant is expected to go into production by March 1964.

The product has been used successfully in various spray-dried protein formulations, and found suitable for feeding infants and weaning children. The infant food formulation is a blend of groundnut protein isolate, skim milk powder, dextri maltose, vegetable fat, vitamins and minerals It contains 26 per cent proteins and 18 per cent fat, and the overall composition is similar to that of infant milk food.

The weaning food formulation is based on a blend of groundnut protein isolate, dextri maltose, skim milk powder, adequately fortified with essential vitamins and minerals. It contains 36 per cent proteins, and 1.6 per cent fat. The product has a bland taste, but reconstitutes readily in warm water. Preliminary studies have shown that the produce is quite effective in the treatment of *Kwashiorkor*, and thus compares well with skim milk powder.

Tapioca Macaroni

A new technique has been evolved in preparing macaroni type of products from a blend of 60 per cent tapioca flour, 25 per cent wheat samolina, and 15 per cent edible quality, low-fat, groundnut flour. A modern type of pilot plant with a manufacturing capacity of one ton of the product per day has been installed at the Institute. Several tons of the material have been prepared for consumer acceptability and market evaluation trials of the product. The tapioca macaroni is more nutritious than rice, and is available in different shapes. A number of dishes can be prepared out of this product to suit Indian tastes. Large scale extension trials among the people of Kerala have established the acceptability of this product.

Wheat macaroni or enriched macaroni and other macaroni products have also been developed at this Institute with a view to stimulating commercial interest in this type of foods. Experimental lots of the material have been prepared and supplied to commercial agencies for the purpose. Import restrictions of some essential parts of the plant have handicapped further development of all types of macaroni food products

Rice Bran Oil

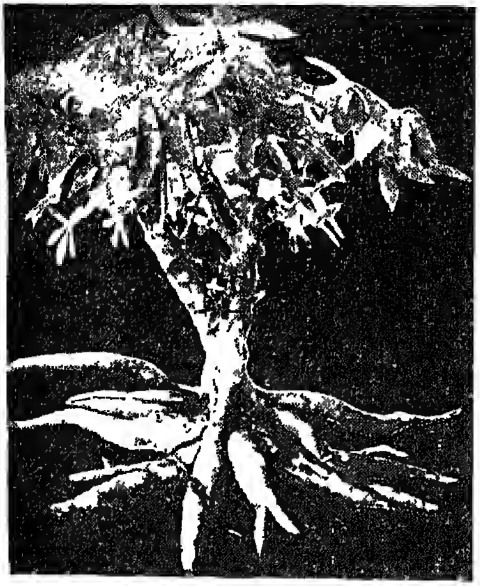
A large surplus of bran is produced during the milling of rice This contains about 16 per cent of the oil. In order to utilize this oil, and release the edible types of oils, a solvent extraction process has been developed at this Institute. This makes use of alcohol/petroleum products to extract the oil from rice bran. A few production units based on the process developed at the Institute have been set up in the country.

Precooked, Dehydrated, Ready-to-eat Foods

New varieties of foods containing the normal types of foods, precooked, equitably blended, and suitably dehydrated, have been developed to obtain light-weight, high-energy, easily assimilable food products with particular reference to the needs of the defence forces. These are of both vegetarian and non-vegetarian types and have been well received by different classes of consumers including the defence personnel.

Storage of Perishables

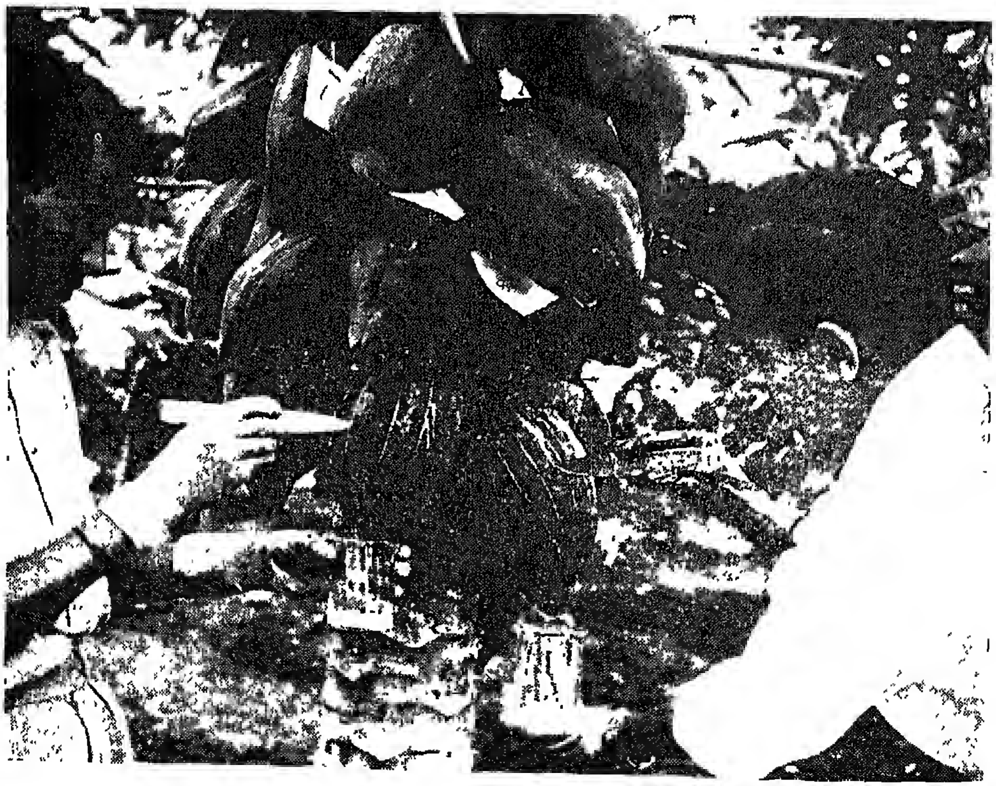
Conditions have been standardised in respect of optimum temperatures and humidity requirements for the prolonged storage of perishables and the cold storage industry in the country have been given



Tapioca plant

Waxing of banana for export trials

Tapping green papayas for white latex (papain)



the required know-how. Work has also been done on quick-freezing of various types of fruits and vegetables.

A fungicidal wax emulsion (a by-product of the sugarcane industry) has been successfully used for coating fruits and vegetables, and this process has resulted in increasing their storage life by at least 50 per cent.

Improved Parboiling Technique

In order to overcome the undesirable off-flavours and unattractive appearance of the parboiled rice prepared in the customary way, an improved technique which consists in soaking the paddy in water at 70-75°C for three hours, has been developed. This technique also cuts down the soaking time considerably.

Papain and Pectin from Raw Papaya

Raw papaya is a rich source of both papain and pectin which are required in the pharmaceutical and food industries respectively. An integrated process for the preparation of pectin and papain has been developed at the Institute, and pilot plant trials have indicated an average yield of 4 per cent of papain and one per cent of pectin. Several parties have evinced interest, and the model schemes have been made available to them.

Mango Cereal Flakes

The Institute has opened a new line for the economical utilization of mangoes by developing a technique for preparing flakes from a blend of mango pulp (49 per cent), wheat flour (23 per cent), and added sugar (28 per cent) The product is similar to corn flakes and can be used as a break-fast food, as porridge, snacks, or even as a thickening/flavouring material for ice creams.

Extension work in Kashmir

Starch and Fibre from Banana Stem

According to a technique developed at the Institute, it has been possible to recover starch (2.5–3.0 per cent) and also utilize the residual fibre for the preparation of paper pulp. Various organizations have evinced interest and the process has been practically demonstrated to them.

As a complement to the scientific activities of the Institute, the Division of Information, Statistics and Extension Services undertakes the dissemination of the acquired information (through co-ordination of information on the results of research investigations, or by documentation) This information is largely oriented to the needs of the actual users in the nation-building activities organised by the Governments (Central and States) through several channels such as the Community Development and National Extension Service Blocks; Small Industries Service Institutes, State Departments of Industries, Food and Nutrition; Home Science Colleges, etc. Liaison work with the industry and the common man is also being vigorously pursued. In this way the objective of the Institute which is not only to develop new processes and techniques, but also to find their application without loss of time, is largely achieved. Thus the Institute is playing an active role in the development of the country's economy

General Science Curriculum for Higher Secondary Classes—I

V.N. Wanchoo

National Council of Educational Research and Training, New Delhi

GENERAL Science, in one form or another, is compulsory in all the states of India up to class V. It is a compulsory subject up to class VII/VIII in all the states except Madhya Pradesh and Uttar Pradesh.

It is taught in all the states of India, except Uttar Pradesh, in the higher secondary classes. At this stage it is a compulsory subject in ten states and optional in Assam, Marathawada (Maharashtra) and Telangana (A.P.). In Bihar, however, students offering natural sciences group as elective do not take this subject.

In Jammu and Kashmir, Madhya Pradesh, Maharashtra (Vidarbha only), Punjab, Rajasthan and West Bengal, general science is taught for two years. In Andhra Pradesh (Telangana Division only), Bihar, Kerala, Madras, Maharashtra (Marathwada) and Mysore, it is taught for three years. In Gujarat, however, it is taught for four years (classes VIII-XI), three years as a compulsory subject and one year (class XI) as optional. In Orissa also it is taught for four years (VIII, IX, X and XI). In Madras and Kerala, general science is the only science which is offered at this stage. Elective sciences are not available in these states. It is, thus, clear that all the students in the higher secondary classes study general science in ten states of India. Uttar Pradesh has the unique distinction of not offering general science at this stage, either as compulsory or as an optional subject.

EXAMINATION

General Science (theory) is examined externally in eleven states and internally in three states. Practical work is examined externally in three states only. In other states, it is not examined even internally.

Although practical work is prescribed in ten states, yet, because it is not examined either externally or internally, in these states, its importance is of doubtful value.

In three states, the marks obtained by a student in general science are not added to his total achievement. It is evident that such a procedure is likely to take away whatever importance the subject may have in the curriculum.

Time Devoted

The number of periods devoted to general science varies from three to six periods per week. The most general

Paper presented at the General Science Seminar held at Varanasi in March 1964.

practice is four to five periods per week, each period consisting of forty to forty-five minutes.

AIMS OF TEACHING GENERAL SCIENCE

Most of the state syllabi do not mention any aims of teaching general science. Two states, however, have given the aims as detailed in the draft syllabus of the All India Council for Secondary Education (1956). A few syllabi have mentioned the approach to instruction in general science. It is, thus, clear that the curriculum committees of the states, appointed for the purpose of drafting the syllabus for general science, were either not clear about the purposes and objectives of teaching the subject at this stage, or did not think it worthwhile to focus any attention on these

It has been mentioned that some states have prescribed some experiments to be done individually by the students or in groups. But this work is assessed internally in one state only. As examination in practical work has not been prescribed and is not, therefore, being taken into consideration for the total achievement of a student in general science, it is apparent that most states were not sure whether such facilities could be made available This aspect needs to be considered very carefully, because, for some years to come, it may not be possible to provide laboratory facilities and science equipment for all the students on the rolls in all the higher secondary schools in India. In fact, the position about the laboratory facilities and science equipment for the elective sciences such as Physics, Chemistry and Biology in most states is not happy Out of twenty thousand and odd high and higher secondary schools in India, elective science at the higher secondary stage is available in about forty per cent of schools only Under the present circumstances, it appears that priority should be given to strengthen the facilities in the schools where elective sciences are taught and to provide facilities for elective sciences in schools where these are not available. Consequently, the Ministry of Education proposes to allot some funds for making available laboratory facilities and science equipment to about six thousand schools in India where such facilities do not exist in the Third Five Year Plan period It is, thus, abundantly clear that for some years to come it may not be possible, under the present financial conditions, to provide facilities for experimental work in general science for all the students in higher secondary schools. It will, therefore, be right to suggest such a type of general science in which minimum laboratory work may be deemed essential

Under these circumstances we propose that for some time to come the main objective of teaching general science at the higher secondary stage may be the development of scientific literacy. Let all the pupils studying general science be acquainted with what has been happening in the present. Science represents an endeavour of man to develop himself, his surroundings and the resources available to him.

There is another aspect which needs consideration in this connection.

NEED FOR GENERAL SCIENCE

After the declaration of India as a Republic in 1949, every adult citizen has assumed responsibility as a voter. He is called upon to express his opinion on various issues, political, social and economic in nature, from time to time Opinions

based on scientific knowledge in some of these issues have become crucial as far as an individual is concerned For example, in a topic such as pest-control, there are two opinions about the use of D.D.T., and other insecticides. It is being argued by scientists that the insecticides may have been able to control the pest life, but at the same time, these chemicals work havoc with the other biological life in the area where they are used. While determining the policy of the state regarding such matters it becomes essential for an individual voter to know several aspects of a problem such as this. It should be the purpose of the core general science at the higher secondary stage to present all aspects of a problem to him so that he can be a well-informed citizen and take decisions on the basis of scientific knowledge.

CONTENT OF GENERAL SCIENCE

A review of the syllabi prescribed by different states indicates that they have heavily drawn upon the draft syllabus proposed by the All India Council for Secondary Education This syllabus consists of units such as 'Our Surroundings', 'Nature of Things', 'Energy & Work', etc. but the items of information under the units have been lifted almost bodily from the existing syllabi of physics, chemistry and biology. Some of these items of information deal with 'Plant Life', 'Animal Life', 'Solar System', 'Air', 'Water', 'Heat', 'Light', 'Sound', 'Magnetism', 'Electricity' and 'Atomic Energy'. The Syllabus Committees of the States have modified this draft as they thought proper. Some items of information have been added to this list. Some items of information have been deleted from it in order to make room for additions. Deletions and additions are more or less arbitrary and no specific purpose has been served. The general pattern of the syllabi is more or less information-centred and the emphasis is on facts of physics, chemistry and biology, without any relation to each other.

There is no mention of any modern development of science in these syllabi Topics such as 'Space Science', 'Rocketry' 'Atomic tests' Electronic Computers', 'Origin of Life', 'Origin of Earth', 'Hybridization' and the like, which have extended man's knowledge over his surroundings and extended his control over nature, do not find a place in these syllabi

The unity of sciences as represented by the recent developments in biochemistry, biophysics, geophysics and other interdisciplinary sciences do not find a place in the syllabi Even the syllabi revised recently do not mention scientific enterprise such as the International Geophysical Year which involved the willing co-operation of the scientists of the world as one community

General science, at the higher secondary stage, is the only science which the majority of students learn at this level in an organised manner A very small percentage of students opt for elective sciences. The question now arises: 'What items of information should be selected for the general sciences course? Should traditional items such as force, acceleration, momentum, oxygen, carbon dioxide, chemical change, dispersal of seeds and the like, be selected or should items such as those mentioned in the above paragraphs, which are exciting, revealing and of a great concern to the present day world, be selected? It can

be argued that both types of items, the traditional and the modern, have their own importance and a message to convey. We have, therefore, selected the minimum quantum of scientific knowledge of the traditional type but of a basic and fundamental nature and made it an integral part of a proposed general science syllabus for classes I-VIII. This syllabus has been published by the N.C.E.R.T. and circulated to the states for their opinion, trial and acceptance. Textbooks and guide materials are being prepared by the N.C.E.R.T based on this syllabus.*

Consequently, we propose to select the items of scientific knowledge of the second type for the general science syllabus for higher secondary classes.

Such a procedure has another advantage as well. A comparison of the content of general science and elective sciences reveals that in many states, a lot of duplication of items exists in them. Several items are taught both under general science and elective sciences If we select items of interdisciplinary nature, those which reveal unity of sciences and the contributions one science makes to the growth and development of other sciences, items which indicate how science is progressing right now and what types of revelations are expected to be mde in future, much of this unnecessary duplication shall be avoided. It may also help to arouse an abiding interest in science in those students who do not intend to study science beyond their higher secondary school career in the university. Such a course may also help to keep alive the interest in science aroused by the unexpected and most recent discoveries and developments in the field.

There is yet another factor of great relevance which needs consideration. The knowledge of science is doubling every 5–10 years. Therefore, recent developments in science deserve precedence over older developments and they should account for a major portion of time devoted to the subject.

With this discussion we propose that the general science syllabus should be a non-laboratory course and aim at scientific literacy. It should draw its content from the recent development of science and from those issues which are of vital importance to man in the near future.

It may be argued by some people that the proposed topic and concepts may prove to be difficult for the comprehension level of students in higher secondary classes. This problem is important and needs to be tackled at several levels, as indicated below:

a. Concepts must be rendered in simple language. Technicalities and mathematical formulae involved should be avoided as far as possible. Many samples of this nature are available in books written in some foreign countries, which may be used as models, to start with.

b. The syllabus proposed and materials such as textbooks, workbooks and guides produced on the basis of the syllabus should be tried out in a large number of schools under experimental and controlled conditions.

c. Guide books for teachers should be prepared which should *inter alia* give background knowledge of all the topic in

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**General Science—Handbook of Activities, Classes VI-VIII* has since been published by the NCERT. This book will help the teachers to develop the concepts in the classroom —*Editor*

the syllabus. This must be done with the co-operation of scientists, methods experts and science teachers on the job

d Teaching learning aids suiting the content matter should be devised

e. Short term refresher courses should be organised for practising general science teachers in all the states which accept and prescribe the proposed curriculum It may be possible to undertake this task in the Regional Colleges of Education, the proposed Institutes of Science Education and through the In-service Courses by the Department of Science Education of the N.C.E.R.T.

The Department of Science Education should also undertake a review of the proposed curriculum after five years and periodically thereafter as the need demands in co-operation with the State Education Departments and the Institutes of Science Education.

Classroom experiments

THE EMPIRICAL FORMULA OF SODIUM HYDROXIDE

IN the introductory chemistry course the students get acquainted with sodium hydroxide at an early stage. It is one of the products of the action of the metal sodium on water. The process actually shows that a gas is released which can be trapped and tested for: it proves to be hydrogen

The second compound formed in the reaction—sodium hydroxide—is invisible, as it dissolves in the excess of water we use, that is the explanation we usually give our students. Testing the properties of the liquid, we find a slippery feeling when rubbed between the fingers, and alkaline reaction Upon evaporating the solution to dryness one obtains a whitish residue We name it SODIUM HYDROXIDE, and explain its formation by telling the students that a sodium atom will only displace one of the two hydrogen atoms in a molecule of water, thus forming a compound NaOH according to the equation

$$2\,Na + 2\,H_2O \longrightarrow 2\,NaOH + H_2$$

That is a sheer statement without any quantitative proof. It goes without saying that, for lack of time, we cannot prove the composition of all the chemical compounds we deal with in our course, the students have to take most of the formulae for granted on the authority of the text or the master that gives them. In some cases, e g., in that of the compound WATER we demonstrate by quantitative experiments in which way a formula can be found

Sodium hydroxide is a compound made up of three different elements, which the students consider to be more complicated than the ordinary binary compounds, whose composition can be more easily understood. I therefore would suggest we should, at a later stage, prove the quantitative composition of one ternary compound It actually can be done for sodium hydroxide in a comparatively simple way, as I have found some years back.

The result of the experiments I am going to describe will show that sodium hydroxide contains the elements Na, O, and H in the ratio by mass expressed by the formula NaOH. (Na : O : H= 23 :16 .1)

Let us first compute the masses and volumes of the substances involved in the chemical reaction by writing up the gram molecular weights and the molar volume

$2\,Na$	$+2\,H_2O \longrightarrow$	$2\,NaOH$	$+H_2\,g$
46 g	36 g		22400 ml

From these data we will calculate the masses needed in our experiments

By courtesy: The Embassy of West Germany, New Delhi.

I. In our first demonstration we will prove that one half of the hydrogen contained in a given amount of water is set free by sodium.

Calculation

One mole of water (18g) is made up of 2g of hydrogen and 16g of oxygen. Those 2g of hydrogen occupy a volume of 22400 ml, the so-called molar volume. The mass of water we will use in our experiment is 0.09 g (equal to 1/200 mole) Thus the volume of hydrogen contained in it is 1/200 of 22400 ml, equalling 112 ml

One half of it will be yielded = 56 ml. It goes without saying that any other mass of water could be used in this experiment, but 0.09 g is a handy number.

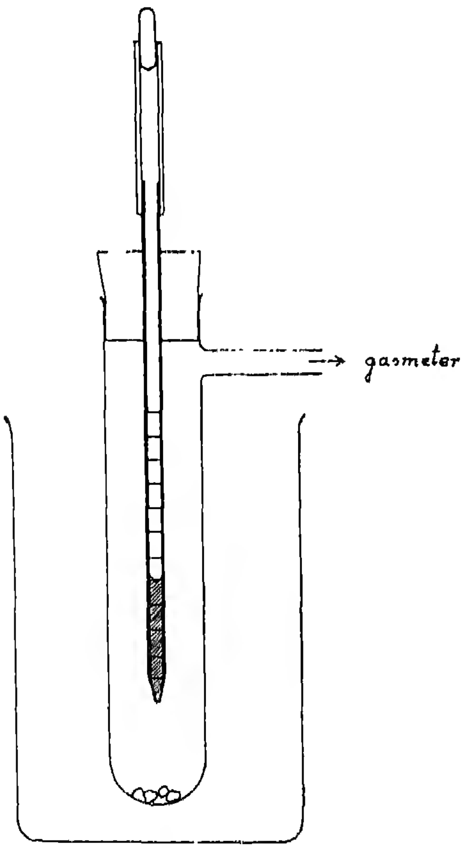


Fig. 1. A given mass of water acts on sodium

A test tube with an outlet connected with some sort of gas-meter—burette or measuring tube– is sealed by a rubber stopper through which a capillary pipette of 0.1 or 0 2 ml is passed. (See Fig 1). The top end of the pipette is equipped with a rubber connector closed by a piece of glass rod.

Upon pressing the hose and then releasing it we fill the pipette with 0.09 ml of water, corresponding to 0 09g. In order to make it visible from distant places it may be dyed. If we add a tiny bit of a detergent, the water will flow out in small drops.

The test tube is placed in a beaker filled with cold water, which will conduct the heat liberated by the exothermic reaction.

Now we place some chips of sodium in the test tube. (It should be noted that according to the equation 0.115g are needed for the reaction, so let it be a little more, say 0.13 g at least.)

We mount the apparatus as shown in the figure By gently pressing the connector all of the water will gradually drop on the metal, setting free hydrogen which is trapped in the gas-meter. Since the resulting sodium hydroxide retains some of the water, we have to heat the test tube very gently when the reaction stops, so as to make the remaining water also act on the sodium. Most of the time that second reaction yields more than half of the hydrogen expected.

After allowing the apparatus to cool down to room temperature, we will find that about 56 ml of hydrogen have been evolved (corrected for standard pressure and temperature).

At the bottom of the test tube we notice a white substance that can be tested for

the well-known properties of sodium hydroxide The excess of sodium that has not taken part in the reaction can also be identified

As shown above, 56 ml of hydrogen represent one half of the total mass of it contained in 0.09 g of water.

Conclusion: Oxygen and hydrogen at the ratio expressed by the symbol OH must have combined with sodium to form the hydroxide.

We now compute the masses of O and H in the compound we have got

mass of water 0.090 g

mass of hydrogen 0 005 g (can be calculated from 1 liter having the mass of 0.09 g)

The difference of 0.085 g gives the mass of the OH group. Subtracting from that amount another 0.005 g, the result is 0.080 g, which is oxygen.

$$O=0.080 \text{ g} \quad H=0.005 \text{ g}$$

II. *The mass of sodium involved in our reaction* can be determined by the well-known experiment whose objective is to find the gram equivalent mass of a metal which dissolves in an acid. As to sodium, water will do. We even must mix it with alcohol, or else the reaction would be too violent The gram equivalent mass of a metal is the number of grammes of that metal which displaces 1 g atomic mass of hydrogen (equalling 11200 ml).

One makes a certain quantity of sodium—let us say 0.1 g—act on dilute alcohol, trapping the gas which is evolved. One way to do the experiment is using a vessel shaped as in Fig. 2. We place 0 1 g of sodium in one of the tubes and about 5 ml of dilute alcohol in the other one. Upon tilting the apparatus both substances mix. Hydrogen is liberated and is passed into a gas-meter, in which its volume is determined. We will get about 49 ml at SPT.

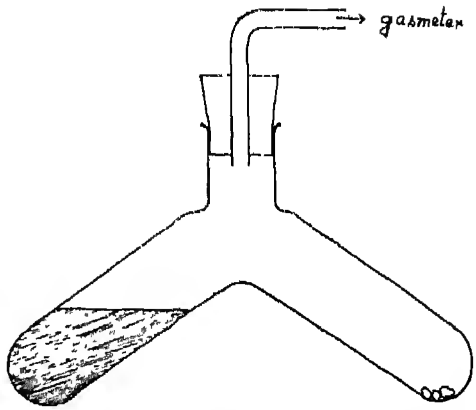


Fig. 2. Determination of the gram equivalent mass of sodium

Calculation

49 ml of hydrogen have been set free by 0.1 g of sodium. 56 ml of hydrogen (result of our first experiment) must have been liberated by 0.115 g of sodium.

Consequently the ratio by mass of sodium, oxygen, and hydrogen in sodium hydroxide is

Na : O . H = 0 115 . 0.080 : 0 005

Upon dividing these numbers by 0.005 to make the value for H=1, we find

Na : O . H = 23 : 16 : 1

The empirical formula of sodium hydroxide is NaOH, since these numbers represent the atomic masses of the three elements.

One may think it dangerous to allow sodium to act on water in a sealed container The experiment has been done many times without anything dangerous happening. The water comes in tiny drops, so that the heat released with each reaction will not start the combustion of the explosive mixture of hydrogen and air Besides, the test tube, with each drop of water, will contain an increasing amount of hydrogen which cannot burn without air.

THEO THEIMANN

DISSECTION AND DISPLAY OF THE VASCULAR SYSTEM OF VERTEBRATES

The best results of dissections for display can be achieved by injecting the circulatory system with a certain fluid, the preparation and method of injection of which are described below. The injection fluid which is brownish red in colour penetrates through the blood vessels and makes them clearly visible by filling and distending them. Such injected dissections can be preserved for years in any suitable preservative and the details of the blood vessels can be distinctly seen.

Materials and Chemicals Needed

1. Plaster of Paris. 2. Mercuric chloride. 3. Distilled water. 4. Glycerine 5. Formaldehyde. 6. Injection pipette. 7 Dissection board. 8. Enamel tray. 9. Nails and pins. 10. Hammer. 11. Scissors. 12. Bone cutter. 13. Cotton. 14. Black paper (thick) 15 Rubber sponge. 16 Sewing needle with thread. 17. Chloroform and jar. 18. Pestle and mortar. 19. Sharp mounted needles. 20 Animal.

Preparation of the Injection Fluid

Take Plaster of Paris and mix it with mercuric chloride (8.0 g of mercuric chloride for every 100.0 g of Plaster of Paris). Add distilled water and make it into a thick paste and grind it well with pestle and mortar. While grinding this, slowly add more distilled water till it forms

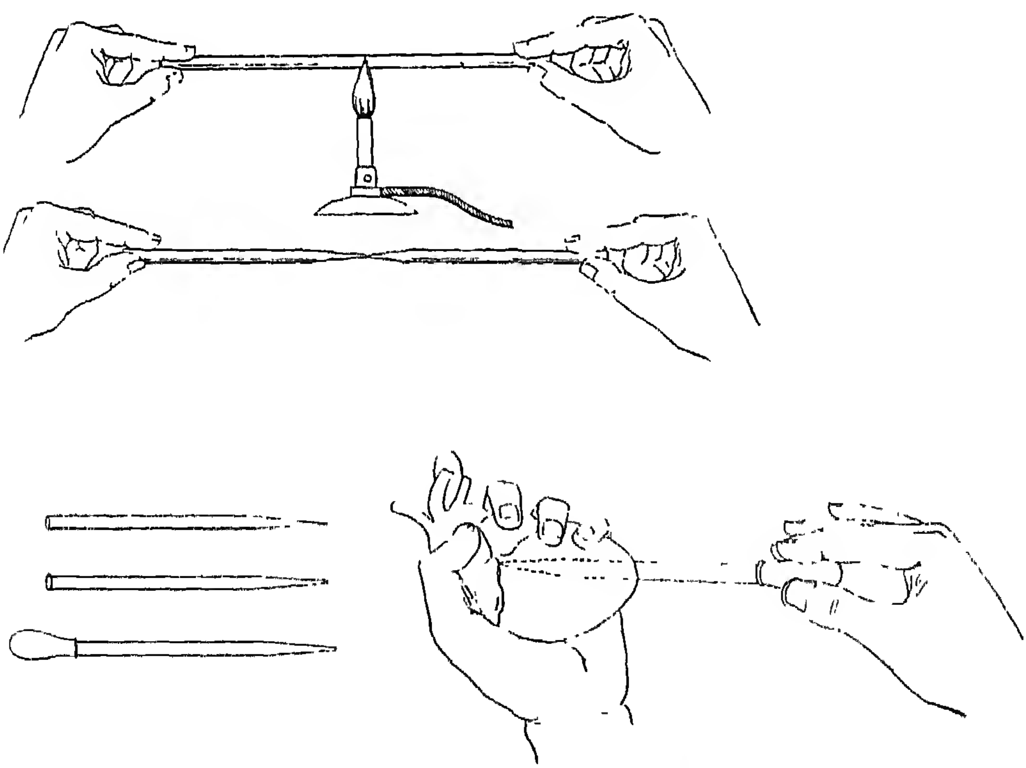


Fig. 1. Preparation of pipettes and the method of injection

a homogenous fluid. Add a few drops of glycerine while the mixture is ground. When ground well, this mixture becomes a solution. To this solution add a few drops of formaldehyde and bottle the solution. The solution should not be very thick. The bottle containing the solution should be shaken well before use.

Method of Dissecting and Injecting the Animal

After chloroforming the animal, arrange it on a dissecting board with its belly side up and nail its limbs. Then cut the skin and muscle layer, to expose the heart. With the help of needles, free the heart from the membranes surrounding it. Do not stretch the animal too much, since some vessels, are likely to get ruptured.

To make the injection successful three steps have to be taken The first is to make a puncture of the heart and make a hole in it up to the root of the artery. This can be done by inserting the pointed end of the pipette through the pointed end of the heart, and slowly by pressure driving it inside in such a way that the tip of the pipette is felt inside the artery or vein. The path can be well established by drawing it two or three times.

The next step is to draw out as much blood as possible from the circulatory system through the pipette. This will make more of injection fluid get into the system and also make the fluid flow easily through the vessels. For this, collapse the teat with your fingers and drive the pipette into the heart and release the fingers. When the pipette is filled with blood draw it out and empty the blood. By repeating this process four or five times much of the blood can be drawn out of the system.

The third step will be filling the pipette with the injection fluid and injecting it into the system through the heart, till no more of the fluid can be injected. Then the vessels just above the heart can be tied by means of a ligature to prevent the injection fluid from flowing out of the system.

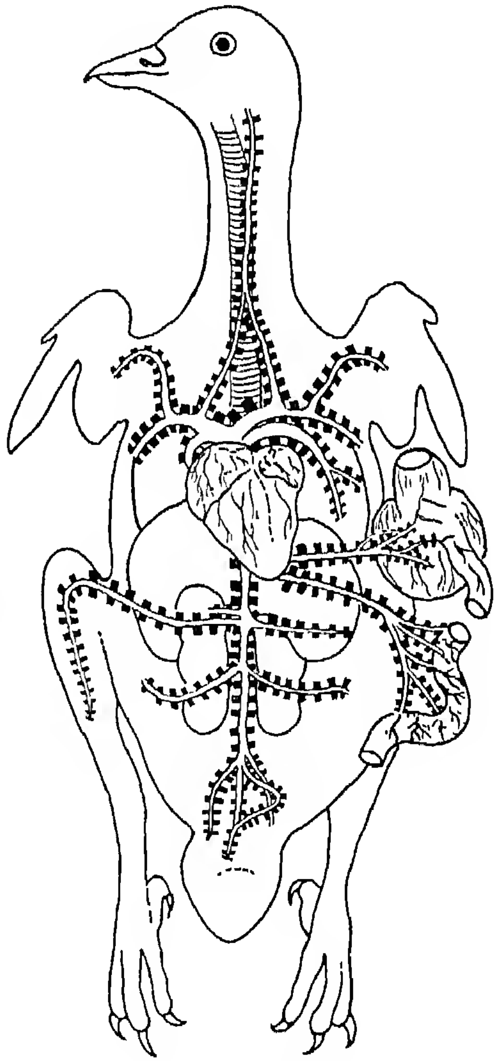


Fig. 2. The display specimen

Display and Preservation of the Dissection

The blood vessels can be traced with the help of the mounted needle and the

surrounding tissues removed to make them visible. In order to make the vessels more distinct cotton can be plugged underneath them and small bits of black paper can be arranged as shown in the figure. The whole dissection can be preserved in 5 per cent formalin and displayed in the museum.

G. RAJU

HOW TO MAKE GLASS

Ordinary window glass and bottle glass can be prepared in a laboratory by heating silica (white sand), sodium carbonate, and lime.

For getting glass of lower melting point yellow lead oxide is used in place of lime.

Green Glass

Take white sand 2 5 g, anhydrous sodium carbonate 2 5 g and yellow lead oxide 2.5 g in a porcelain crucible and heat them strongly with a Fisher burner or with a blow pipe flame. The mixture melts into a fluid mass. To give a green colour to the glass, add some crystals of chromium oxide to the molten mass. Pour the molten mixture on an asbestos mat. The drops on cooling will become sparkling bits of green coloured glass.

Blue Glass

To the molten mass as obtained above, add some crystals of cobalt oxide in place of chromium oxide and repeat the process in the same way. Sparkling bits of blue glass will be obtained.

Other Coloured Glasses

Traces of certain other metallic compounds can be added to the mixture before heating, to give different colours to glass. Copper sulphate gives blue-green colour, while ferrous sulphate a yellow green colour. Manganese dioxide gives a colour varying from amethyst to black

Water Glass

Dissolve sodium silicate in water slowly until a syrup-like fluid is formed. It is called water glass (only silicates of sodium and potassium are soluble in water)

It can be used as a thick cement for glass and china Take two broken pieces of glass and heat the portions to be cemented and apply water glass and then clamp the parts tightly together until the glass is dry.

In order to prepare a better variety of cement which can withstand greater heat and action of acids, take thick water glass two parts, fine sand one part, and ground asbestos one part, mix them together and apply in the same manner as explained above.

Glass from Water Glass

Heat a small amount of the water glass in a crucible until all the water is driven off and a fluffy white solid remains behind. Mix a little powdered chalk with this and then reheat with a blow-pipe. Mixture melts and fuses into a bead of glass.

Glass as Drying Agent

Take 10 ml of thick water glass prepared as above, in a beaker and add 10 ml of pure water to dilute it. In another beaker take 1 35 ml of concentrated hydrochloric acid and dilute it with water to a volume of 15 ml. Now pour both the solutions prepared separately into a third beaker simultaneously and go on stirring with a stirrer (rod). Within a few seconds a solid whitish gel, will be formed. Allow this whitish gel to dry. Glass with minute pores will be formed This can be used as a drying agent

K.S. BHANDARI

Science abroad

Nuffield Foundation Science Teaching Project—II

THE PHYSICS 11–16 PROGRAMME

THE physics course aims to give knowledge and understanding of physics, as part of modern science, to three groups of pupils:

(*i*) Those who will leave school at 16, and those who will continue at school without meeting more science. The course must therefore be complete in itself.

(*ii*) Those who will continue with more advanced specialist work, either in physics or in other sciences, from 16 to 18.

(*iii*) Those who will continue with some informal science while they specialize in other subjects at sixth form level

Aims and Structure of the Programme

Group (*i*) makes the strongest call on the planning, because this is the only chance for that group to gain an understanding of physics (and of its relevance to everyday life).

These educated adults will not remember the facts of physics clearly and usefully, or even the great principles, unless they understand the science they are taught. They should be taught understanding rather than a short-lived knowledge of formal statements or a skill in solving problems with formulae, or success in following routine instructions in the laboratory.

If physics can be taught in a way that meets, in some measure, the aim of constructive understanding, this treatment should also give groups (*ii*) and (*iii*) better preparation, in the long run, than more rigorous training

Both pupils and the outside world ask to be taught some 'atomic physics'. To gain time to do this, some older material has to be omitted. It is also necessary to provide a good preparation in electricity and dynamics, especially in what we teach about energy. A sound, growing knowledge of energy is being made a binding strand that runs all through the course. And by developing new demonstration apparatus and simple kits for class

Paper presented at the Commonwealth Conference on the Teaching of Science in Schools, held in Peradeniya, Ceylon, in December, 1963. *Continued from the previous issue*

experiments both dynamics and electricity will be made easier for the teacher to teach and the pupil to understand.

To understand science, pupils need some first hand experience of a scientist's experimental work. So some class experiments are offered for them to do on their own, with encouragement and some guidance from the teacher, but not 'cookbook instructions'. Even with simple, flexible kits, those experiments will take much time, so new demonstrations will be suggested to replace other class experiments

Ultimately pupils should understand physics as a well woven fabric in which experiment and theory play complementary parts, and to think of scientists as intelligent, sensible, skilful and imaginative people. The material chosen for the syllabus should, therefore, fit together, so that one topic helps another and a later topic reflects back on an earlier one. Also pupils must do constructive thinking, and learn to use their good sense, skill and imagination both in the laboratory and in homework—and even in examinations.

An examination group is collecting, devising and editing specimen questions for homework and tests. A corresponding change would be needed in public examinations, both in the asking of questions and in the treatment of answers, but, to skilful examiners, these changes should not prove too difficult or unwelcome, and it is hoped that examining boards will be willing to experiment with them.

Much of the present work is concerned with setting things forth for schools and teachers who wish to try the suggested course, guidance for teaching, details of new apparatus, reasons for expanding one part of the teaching and reducing another. The apparatus and written material and films developed so far are regarded as suggestions to a physicist who is keen to try new teaching. They are not offered on an 'all or nothing' basis, or as a set pattern to follow slavishly. Yet, since the aim is to teach for understanding, the treatment of one topic does link with another; the kit of apparatus for one experiment does provide for others; the question for homework does open up further questions for thinking and experiment. The scheme strives to be a living organism of good teaching

Materials in Preparation

The teaching and learning aids will include:

- (*i*) New apparatus, kits to provide for several simple class experiments in succession, demonstration apparatus to make certain topics easier to teach quickly and clearly; and short films to illustrate special concepts, or to show inaccessible or difficult experiment.
- (*ii*) A handbook for teachers, as a short guide to the course.
- (*iii*) A guide for teachers, offering much fuller discussion. This will contain comments, advice, discussions of aims and descriptions of methods, outcomes to look for, and a running outline of the teaching syllabus. It will contain some commentary on class experiments and demonstrations, and examples of questions for homework and tests.
- (*iv*) A collection of questions and problems for homework and tests.

(*v*) A teachers' guide for experiments, giving details of apparatus.

(*vi*) Pupils' guides. These will provide reading for pupils, and we hope they will take some burden off the teacher It is planned to have them written by practising teachers and edited for general conformity and standard of treatment.

(*vii*) Films. The short films mentioned above in (i) will be made for use in the 8 mm Technicolour projector. We are also making some films that are not intended for pupils but as guides for teachers to useful techniques with new apparatus.

Samples of the General Approach Adopted

As an indication of the general thinking, two extracts are given from the notes prepared for teachers who are trying out parts of the programme.

First Year (*11 to 12-year-old pupils*)

This is a year of gaining acquaintance with materials and their properties and behaviour, and instruments, and the way in which scientists do things, and just a little of the way in which scientists talk. It is a year of seeing and doing with very little to be learnt by heart or recorded in a formal manner.

When children do things themselves they need a long stretch of time. They are, in a sense, being young scientists when they do class experiments, and just as professional scientists are not given a book of instructions or required to get the 'right answer', children—if they are to see how science is done—need to be left alone, with encouragement but no more instructions than are absolutely necessary. The teacher can start the question, make suggestions, offer criticisms, give encouragement, but he should not hurry children through. Finishing each experiment at the right instant, with a proper record of it, and hurrying on to the next with full instructions, looks efficient but has not produced a generation of educated laymen, who enjoy the feeling that they understand physics.

Throughout this first year and the next, teachers should consider they are encouraging young scientists to gain in knowledge, and a little in skill, and they should remember that there is no piece of material knowledge specified in the syllabus which cannot be learnt later on very easily if it is missed now. The motto for this year and next is gaining a sense of knowledge by seeing and doing, and using instruments to find out.

Instead of giving a logical sequence of investigation leading to formal conclusions, and rules and principles followed by systematic uses, let children build familiarity by use, then illuminate the familiar thing by investigation and explanation. Thus, we may give a child a very simple ammeter and encourage him to use it and find what ammeters do—all this before explaining how an ammeter works or even what an ammeter is meant to do

In the past, many a child has owned and used a good conception of the conservation of mass without any question being raised, or definition being given, or investigation being demonstrated. We can begin by taking atoms and energy for granted in the same kind of way.

To leave all knowledge of science in that naively accepted state would be to

do science, and our pupils, a serious disservice, for it could build up a picture of science by authority which might even turn into the nonsense of the mediaeval schoolmen. But we can give children a feeling of progress—'nothing succeeds like success'—if we let them start with some naive acceptance. That would be bad teaching for adult would-be logicians, but it is good teaching for young would-be scientists.

For example, we shall talk of atoms as the smallest bits of stuff. We ask gently, 'how small ?', and give no answer—nor at this stage put any question of how to approach one—let the question nag, as it will in even the young mind. We shall say atoms and molecules are in constant motion · but since that is not a common-sense knowledge, we must at once give some justification from real life: the Brownian motion—not just talked about, not shown by a large model, not by films which seem remote, but the real thing seen with a microscope. That means the laboratory needs to borrow enough microscopes for each child in turn to get a look, and that means the child must have already used the microscope for something more familiar. It is one of the many instruments we should help children to use and understand in physics class That is why we suggest having children use a magnifying glass and then a microscope early in their exploration 'concerning the nature of things'.

Before coming to those instruments, children should use similar ones that are already familiar. So we start with samples of material on view—brass, glass, lead, sand, water—and make simple measurements to add a feeling for density (to make that easy and quick, we offer rectangular samples, and direct reading balances) We let notebook records be short and simple; and we do not—yet—burden the story with discussions of accuracy or long arithmetic for great precision.

That brings us back (going backwards in the syllabus) to the beginning of our course for eleven-year-olds: a shelf of many materials to be looked at, handled, weighed and measured. The children do not need to write notes on these; in fact they should not, or the pleasure of enlarging acquaintance may well be dulled by formality. In our own childhood, some of us have scratched a window pane with a diamond, watched a water-flea's heart beating, or choked with chlorine, but we did not write a neat notebook report. Nor did we write an explanation saying the diamond ploughed into the glass because it is harder (!) or a story that diamond is harder because its atoms are close packed in a tetrahedral molecule.

Treated like that, our collection of samples (staying on the window sill for weeks) needs no lecture from the teacher; but, farther along the line, crystals may start discussion, and the teacher should show some crystal models. That will start talk of atoms arranged in regular array 'How small are they ?'.. 'Suppose atoms were as big as marbles ?' .

FIFTH YEAR (*15 to 16-year-old pupils*)

This is a year of important experiments and ideas in which we draw upon the work of previous years but expect more imaginative thinking, more reasoning and new experimenting. We want to develop some taste for theory and to explore further in 'atomic physics' in both experiment and theory.

Newton's Laws of Motion—so far treated as great principles and tested in simple class experiments—are now put to the use that Newton himself set forth: to form a grand theory of the planetary system. For that we must have a quantitative treatment of circular motion; to be done by an experimental approach where pupils find the geometrical discussion too hard. Then, armed with some understanding of orbital motion, we can continue previous work on electron-streams by bending their path with a magnetic field. Here, to analyse measurements, pupils must use some knowledge of the force exerted by a magnetic field on a stream of charged particles. That is difficult, but we shall not evade it (thus losing our chance of clear knowledge of electrons) or spoil it by announcing an unexpected 'formula': instead we shall make a direct experimental approach and measure the effect of the magnetic field that we use, by putting a simple current-balance in it. (For pupils who find this work too hard, we shall offer a qualitative treatment which will be shorter and will leave more time for the other topics of this year.)

Then, while simple atomic models are being discussed, experiments on radioactivity will be carried out along the lines of the S.M.A.—Nuffield Foundation report on the 'Teaching of Modern Physics'. This work will open up new knowledge and help to encourage the imaginative thinking by which the scientist formulates a model.

A simple study of waves and oscillations will be resumed from earlier years. That will lead, on one hand, to estimates of wavelengths of light by interference—for use in building atomic models—and on the other hand to experiments with alternating currents—for use in ordinary life.

As the discussion of atomic structure continues, films and demonstrations will help to carry pupils as far as the ability and knowledge of each class will allow. For classes that find this difficult, the development will proceed more slowly, and more attention will be given to some practical applications of modern physics in class experiments.

All through, the important thing for teachers to keep in mind is the overall view that they are giving to pupils who will end physics now: the knowledge of physics that those young 'scientists for a day' are gaining, and their picture of nature, explored and well-understood up to a point, then bounded by new regions of unfinished knowledge. Here at the end, as in the earliest years, we hope pupils will conclude that 'science makes sense'.

THE CHEMISTRY 11-16 PROGRAMME

The Chemistry Section aims to provide an education through chemistry for children in the 11-16-year age-group and, at the same time, to offer a sound basic training for future chemists among them. The Section's work will affect, ultimately, three groups of people pupils, teachers and examiners.

Pupils

Throughout the educational world, there is general agreement that present-day science teaching should place much more emphasis on imaginative enquiry and the judgment of evidence, and much less emphasis on dogmatic assertion and the memorising of facts. With this outlook in mind, the Chemistry Section has

been governed in its work by the following principles

(a) A clear distinction should be made between experimental fact and theoretical explanation. Ultimately, pupils should appreciate how science develops from the inter-play of fact and explanation.

(b) Pupils should be familiar with the changing pattern of experimental techniques and of modern trends in chemistry. In particular, they should learn about the many exciting new substances which modern chemists are making and about the contribution of energetics to a new understanding of chemical reactions.

(c) Although pupils should know about the broad principles and overall patterns of chemistry, they should also be aware that explanations have to be checked and may have to be changed. Science should be presented to them as a flexible way of interpreting experience and not as a rigid system for discovering 'truths'

(d) Pupils should be encouraged to think imaginatively and to explore ideas for themselves.

(e) Pupils should develop their judgment so that they can determine whether or not a problem can be answered by scientific investigation and, when it is so investigated, whether or not the evidence and its interpretation are acceptable.

Teachers

Teachers will have much greater freedom than previously to select the content of their courses and to handle the approach in line with their own ideas and the needs of their pupils. It is not the intention to replace one dogmatic approach to teaching by another, and what the Section will offer is a framework of thoroughly-tested ideas in which there is considerable room for individual manoeuvre. At the same time, many teachers would welcome initially a tested clear-cut scheme whereby they could try out the new ideas for themselves. The Section will cater for this demand by providing such a scheme, laid out in detail lesson by lesson.

Examiners

To achieve individual flexibility, the type of questions set at public examinations will have to be carefully re-appraised. If the present scheme is to succeed, the examinations will have to place much more stress on testing the pupils' judgment and much less on testing their memories. Part of the work of the Section is to look into suitable-type questions for examining the scheme.

Framework of the Scheme

The broad outlines of the framework which have been worked out in close consultation with the Physics and Biology sections, are as follows:

Chemistry as a manipulative and intellectual activity. As a result of investigations and problems undertaken during the course, pupils should have acquired skill and understanding of the following:

(1) Getting new materials from old;

(a) *Making the change happen* - adjusting conditions to bring about a desired change; use of thermal

energy and electrical energy; altering equilibria and rates of reactions.

(*b*) *Knowing whether or not something new has been obtained*—isolating gases, liquids and solids in a state of moderate purity so that an operational meaning of chemical individuality is acquired. This entails familiarity with such procedures as fractional and steam distillations, crystallization from water and other solvents, use of vacuum pumps and centrifuges, chromatography and ion exchange. It also implies ability to test whether or not the aim has been accomplished—use of melting point, boiling point, and simple chemical tests.

(2) Looking for a pattern in the behaviour of substances:

(*a*) *Reperesenting and interpreting qualitative and quantitative results*—assessing evidence.

(*b*) *Finding and seeing major patterns of behaviour, and assessing their importance*—examples of this are acidity and alkalinity in aqueous solutions; metallic and non-metallic nature; electrolytes and non-electrolytes, and the periodicity of properties of elements.

(3) Explaining changes in terms of atoms and electrons, and learning how to check theory against fact. Using critically the ideas of atoms, ions, molecules, giant structures, and types of bonding as ideas put forward to explain facts; the planning of experiments designed to test suggestions, and the change from use of grams to the use of gram-atoms and gram-formulae as an aid to speculation.

(1) Using energy changes as another means of checking theory against fact. Measuring 'the heat of a reaction' as a guide to changes in bonding; using tables which give heats of reactions and the work that can be obtained from reactions

Chemistry as the product of manipulative and intellectual activity—The information pupils collect may well be influenced by the interests of their chemistry teacher. Nevertheless there will be certain basic information that they will need to know. Most of this information will have been in the traditional course, but the justification for studying it and the approach involved will be different Some information will belong to the less-traditional areas of study as, for example, electro-chemistry and corrosion, polymerization and carbon compounds Pupils, too should be familiar with the work of other people. This does not mean a course in potted biography, but a few well-chosen examples of exciting minds, of the flash of genius and of the fact that chemistry is a product of people's activity, to place the subject in a human perspective. For example, pupils should have some knowledge of the way that the concept of an element, the concept of atoms, and the concept of energy have developed.

Lastly, at the end of the course, exploring the behaviour of substances should be linked with other scientific studies so that science is seen in relation to the life of the community as a whole—not only in the sense of direct application but also

s an addition to a body of experience which greatly affects our lives and our sense of values.

Publications in Preparation

(1) A HANDBOOK FOR TEACHERS—Intended as an introduction, a brief outline will be given of the Chemistry Section's proposals and a lesson-by-lesson scheme based on these proposals.

(2) TEACHERS' GUIDE—This book, to which many teachers are contributing, will discuss more fully the Section's proposals and will offer advice to teachers about the handling of numerous difficult topics. Detailed treatment of the five-year scheme of lessons listed in the 'Handbook' will be given The book will also include class and demonstration experiments written up from the teachers' viewpoint, with advice about the approach to, and follow-up of a given piece of experimental work

(3) PUPILS' EXPERIMENTS BOOK—Instructions will be given to pupils for performing many experiments. The instructions will be designed to encourage a variety of aptitudes—for example, planning of experiments, disciplined speculation, accurate observation and problem solving—but will always leave something for the pupil to contribute himself.

(4) HANDBOOK OF NUMERICAL DATA—Tables will be given of fundamental constants, atomic properties, energy changes, electrical properties and similar phenomena for most elements and for a wide range of compounds It is intended that the book will be used for pupils not only for reference but also as a major teaching aid—for the extraction of information and interpretation of evidence, etc. Use of the book in examinations will allow the setting of suitable problem-type questions.

(5) BACKGROUND READERS— The intention of these Readers is to amplify and extend work done in class, and to stimulate the interest of pupils in wider aspects of their study. Each Reader will cover a separate topic and, in addition to factual and explanatory information, will delve into the historical and industrial background of the topic

Teaching Aids

The Chemistry Section encourages extensive use of the modern teaching aids that are now available. A series of 8 mm films—to be shown in a daylight-viewing back projector—will be produced for use with the scheme, as will slides, charts and models. In the preparation of these teaching aids, the aim throughout will be clarity of communication and singleness of teaching purpose.

THE BIOLOGY 11-16 PROGRAMME

The biology course is hoped to evolve aims to serve three purposes:

(i) To provide a sound introduction to modern biology for those children who will leave school at the age of sixteen. As such the material used will need to be a complete entity.

(ii) To contribute a suitable background for more advanced specialist work for biology students from 16-18.

(iii) To provide a basis for further courses of science at sixth form level for non-scientists.

Materials in Preparation

A set of documents and other teaching materials are to be produced, aimed at achieving these purposes. The range of materials will include:

(i) *A textbook for students* written from a much more experimental standpoint than existing English textbooks This will cover practical work, much of which will be of a quantitative kind, the idea being to show that the study of living organisms is not only as much a branch of experimental science as are physics and chemistry, but also that it poses peculiar and exciting problems of its own. It will also deal with the assessment of second-hand evidence, i.e., the experimental basis for factual material which at present we tend to accept too uncritically and to learn by rote. Biology will be 'presented as a unified subject, not as two separate disciplines—botany and zoology. An important facet of biology teaching is the close integration of what is taught in the classroom with what is discovered in the laboratory. in the Nuffield biology programme it is intended that theory and practice should occur side by side, and the laboratory guides will be inter-woven with the students' texts rather than published as separate volumes.

(ii) *A guide for teachers* which will be mainly concerned with suggesting ways in which specific topics might be put over and will be closely cross-referenced to the relevant sections of the students' text It will also serve as a guide to the preparation and conduct of laboratory demonstrations and class practical work. In particular it will suggest ways in which standard class experiments may be elaborated at different levels of sophistication without additional apparatus, to provide a challenge for the more able student.

(iii) *A book of projects* intended for the most gifted students and for those who show particular aptitude and enthusiasm for experimental work. Here again, the topics will be related to the work in class and will often be direct extension of it. Each project will be annotated with suggestions for possible lines of approach, and appropriate reading list provided. It is envisaged that this work could be done partly in the students' spare time.

(iv) A set of good *visual aids*. Both students' texts and teachers' guides will be copiously illustrated with diagrams and pictures. Apart from these, a set of short films (each of about three minutes' duration) will be produced dealing with specific topics (e.g. cell division) and intended as an integral part of a particular

lesson. It is hoped that they may be relatively cheap and that the schools will possess their own sets The Technicolor 800-E apparatus (8 mm) will be used Also much enlarged electron-miscroscope and other photographs of living material such as cells, viruses and chromosomes will be provided in sets either to be pinned up, handed round a class or projected from an episcope if a black-out is available. These will also be produced eventually as 2″—2″ lantern slides.

Nature of the Course

The biology 11-16 course will be built round a number of fundamental problems Such themes as the relationship of structure and function, the interaction of organism and environment, adaptation and natural selection, will recur again and again in different contexts over the five-year period, so that a sound operational understanding of them may be acquired by all pupils.

An aspect of biology teaching which will receive much attention is its integration with physics, chemistry and mathematics. The texts and teachers' guides will be cross-referenced to appropriate portions of the relevant physics and chemistry volumes produced by the corresponding Nuffield Projects, and with those of the School Mathematics Project based at Southampton University. The links with chemistry we regard as especially important. and it is intended to collaborate with the Chemistry Project in the writing of two documents concerning those areas of chemistry of particular relevance to biologists One of them will be written by a biologist and the other by a chemist presenting the same material from two different viewpoints.

It will be important, too, to emphasise the fact that biology possesses a dimension not found in physics and chemistry—the capacity of living organisms to maintain what are, in effect, highly unstable systems and to utilise them as a means to survival.

Aims in View

In selecting basic concepts considerable thought has been given to what the aims of an elementary course in biology should be. These aims are

(i) To develop an understanding of man's place in nature. Roughly, the aims here are four:

(a) to study man as the principal mammalian 'type',

(b) to give some idea of the 'usefulness' of biology in relation to man's everyday needs,

(c) to make students aware of the profound influence of the activities of man on wild organisms and

(d) to provide some understanding of the way in which biology enables man to interpret observations that he makes every day.

(ii) To further a realisation of the variety of life. This is a difficult aspect to tackle at an elementary level and yet it is obviously important. Inevitably, the core of any course has to be based on a study of flowering plants and mammals, particularly man.

An increase in the amount of ecological fieldwork should also help greatly to widen the students' view of the animal and plant kingdoms The provision of simple 'keys' for plant and animal identification is going to be important here.

(iii) To encourage a respect and feeling for all things living. Biology is, after all, the science of living things, although from what goes on in the name of biology in many laboratories up and down the country one would find this hard to believe There is no single means of achieving our end. Use of living organisms for study wherever possible will obviously help, killing only when killing is really needed for proper study. What are the ideal plants and animals for investigation indoors? Again, field-work leading to a knowledge of organisms in their wild habitats is surely essential.

(iv) To develop a contemporary outlook on the subject. This does not, of course, imply that every child of sixteen should be a potential 'molecular biologist' in outlook Indeed, it seems essential to resist the idea that in order to study a living organism one has first to tear it to pieces. There are, however, certain areas of biological knowledge where conspicuous advances have been made and to which little respect has been paid in present day syllabuses. Cytology, genetics, evolution, ecology and physiology obviously require greater emphasis in a contemporary approach.

(v) To teach the art of well-planned observation, the proper formulation of question and the designing of observational and experimental methods including the use of controls. There now seems to be fairly widespread awareness of the inadequacy of laboratory work in schools. As far as Nuffield Biology is concerned, the task is to produce a series of experiments which will promote an attitude of enquiry rather than one of unimaginative verification. The problem consists only partly in designing new practical work; it is equally a matter of re-orientating our approach to much that already exists.

(vi) To develop a critical approach to evidence. No one will deny that far too much of our present science teaching merely involves an uncritical assimilation of facts. If our approach to practical work is to be re-orientated, clearly the presentation of theory must be in sympathy with it. When considering generalisations, must we not try to produce some of the practical evidence on which they are based? The writing of more lively texts will certainly help; but, once again, the eventual solution of the problem rests in a radical change of teaching approach, a change which only the teacher himself can bring about.

(vii) To encourage and develop an attitude of curiosity and enquiry All teachers would agree that such an attitude is innate in the majority of children entering our secondary schools How much of it remains two years later? How often do we fail to grasp a precious opportunity of developing a facet of human personality which will colour the rest of a child's scientific learning? The problem serves to underline once again the need for an objective and enquiring attitude, especially during the introductory years

(*Concluded*)

Recent Developments in Secondary School Science in Australia

AN attempt has been made in this report to summarize the information received from the six individual states.

Organisation

GENERAL

STATE	MINIMUM LEAVING AGE	SCHOOL YEARS		NOTES
		PRIMARY	SECONDARY	
Western Australia	End of year in which pupils turn 14	7	5	
Queensland	14	8	4	Pattern changing to 7+5. Leaving age to be raised to 15
New South Wales	15	6 or 7	5	Sixth year secondary being added.
Victoria	14	6 or 7		Leaving age 15 in 1964
South Australia	15	7 or 8	5	
Tasmania	16	7	5	

Note: A considerable proportion of pupils continue beyond the statutory minimum leaving age.

Paper presented at the Commonwealth Conference on the Teaching of Science in Schools, held in Peradeniva, Ceylon, in December, 1963.

SECONDARY COURSES - SECONDARY SCHOOLS

YEAR	*W.A.*	*Q'LD*	*N.S.W.*	*VIC.*	*S.A.*	*TAS.*
1	GS or Sep	Sep ϕ	GS*	GS	GS or Sep	GS
2	GS or Sep	Sep ϕ	GS*	GS	GS or Sep	GS
3	GS or Sep	Sep ϕ	Sepϕ	GS	GS or Sep	GS or Sep
4	Sep	Sep	Sepϕ	GS	Sep	GS or Sep
5	Sep		Sep	Sep	Sep	Sep
6				Sep		

*Recent change

†Change being implemented to provide GS in place of separate science

GS A 'generalized' science which may be called General Science, Science, Elementary Science

Sep Separate sciences. Physics and Chemistry are almost nation-wide, except for some girls' schools. Biology is very popular in most States. Other separate sciences include Agricultural Science, Geology, Physiology, Botany, Zoology.

Management and Guidance

In general the pattern is similar for the various States. Courses of study for the early secondary years are planned and guided by individual schools, groups of schools and representative committees heavily weighted with practising teachers, advisors and inspectors. In later years, when public examinations appear, University and/or lay representation on planning committees begins to become significant. In some States universities' directive influence is being replaced by guidance particularly in school years other than that concerned with matriculation.

Matriculation is in the final year in each case except South Australia which awards matriculation at the end of its fourth year at present, but which plans to change to a final year Matriculation in 1965.

SYLLABUS AND COURSES OF STUDY

Broad Survey

Separate reports from each of the States indicate the existing situation. Some broad trends which may be appearing include :

1. Acceptance of a broadly based science course for *all* pupils up to the age of about 15 years.
2. Consolidation of the place of physics and chemistry as basic separate sciences.
3. A lively interest in, and some acceptance of, changes in content

and methods of presentation of all science subjects.

4. An increase in biology as a school subject.
5. Increasing emphasis on the place of practical work in all science courses.
6. Increasing acceptance of the idea that fundamental concepts should form the basis of courses, that a course should be integrated by using these fundamental concepts and that the several sciences are themselves inter-related. Opponents of these ideas express themselves on the grounds that such courses may tend to become inappropriately academic and may fail to recognize the pupil's desire to explain and understand significant environmental applications.
7. A demand for sufficient time to allow differential rates of progress and to encourage the use of pupil-discovery exercises.

EQUIPMENT, BOOKS AND AIDS

Methods of Supply of Equipment, Chemicals and Materials

Schools obtain equipment, chemicals and materials in various ways in different States and systems. These ways include:

1. Purchase from school funds or from a science fee.
2. Purchase from Government grant.
3. Supply by Government contract and delivery direct to schools from successful tenderers.
4. Supply from a central Government store, either following application by the school or as standardised supplies for new schools.

The first two of these have the advantages of control of quality by personal buying but, except where schools are long established or generously endowed, providing sufficient quantity is often a problem. The latter two have the advantage of bulk buying at competitive prices, they encourage new suppliers to enter the field and, by using a central store, some measure of quality control is maintained. Delays between application and supply are sometimes a problem in the third and fourth methods of supply, but in general, small schools are more liberally supplied by these latter two methods.

Range of Equipment and Materials

Commercial suppliers are able to provide a full range of apparatus for all sciences, much of which is locally manufactured. Syllabus changes which necessitate new equipment items cause little difficulty, local manufacturers showing increasing willingness to produce prototypes quickly. Some problems of large-scale supply have been experienced in the electronics and atomic fields. Imports of suitable but cheap items from Asia and Europe have stimulated competition and have enabled schools to provide more liberal supplies particularly in optical equipment. The Australian chemical industries are developing steadily and the range of chemicals necessarily imported is decreasing. Institutes, professional organisations, mining companies, Government departments and private companies contribute significantly, either by gift or sale, such items as geological specimens, biology specimens and slides and samples of industrial process products.

Expenditure is difficult to assess, but £1,000 per year for a school of 800–1,000 would not be uncommom.

Books

Local book-writing has increased in recent years and most science courses are now satisfied by a local product Work in this field might be summarised conveniently as :

i. Books written by panels with the idea of providing guidance and interpretations for an expressed course of study, often suggesting possible methods of approach but not intending to prescribe the teaching of the subject.

ii Books written by individuals about a special science or general science with sufficient attention to contemporary trends to invite teachers to prescribe these books as textbooks

iii. Books written by individuals to supplement existing textbooks where these are found to have shortcomings with respect to courses being studied

The Australian publishing industry is developing. Competition from Government publishing resources, particularly in recent significant publications in New South Wales and Western Australia and from American sources when the quality, format and style of publications display added attractiveness, are serving to increase commercial publisher's alertness and initiative.

Supply of Books to Pupils

Different States have different systems, including individual purchase, rental systems and free supply. There is a general trend towards each pupil having a copy of a textbook for his own use and a fairly strong trend towards increased library facilities appropriate to science at each level. Sets and individual copies of reference books, periodicals and magazines on individual topics are common in many school or subject libraries.

Aids

Hundreds of charts are available from a wide range of sources. Most of these are excellent in quality and as teaching aids. Costs vary considerably, imported charts tending to be rather expensive State Government departments have developed their own branches for the production and reproduction of visual aids including charts and films. Film strips are extensively used and movie films, readily borrowed free from Government film centres or hired from agencies continue to find increasing use in science teaching. Local production of models, slides and photo-micrographs is meeting an ever-increasing demand.

Radio and Television

Radio has provided time for science broadcasts for many years. Most of these broadcasts are locally produced by practising teachers and lecturers. Currently, television time is being provided for presentation of school science topics, and several programmes on television intended for general viewing, have proved significant for senior school science pupils. The use of television for some aspects of teacher training is proving popular and valuable Most states have special committees to investigate, plan and produce television material and techniques.

Recent Developments in the Teaching of Science in New Zealand Schools

PRIMARY schools take children from age 5 to age 13+. In many areas, pupils are transferred at about 11+ to Intermediate schools where they stay for two years (Forms I and II). Secondary schools commence at Form III (age about 13). Some pupils leave on attaining the age of 15 years. School Certificate Examination, conducted by the Department of Education, is attempted at the end of the third year (Form V). University Entrance Examination, conducted by Universities Entrance Board, is taken at the end of the first year in Form VI. A competitive Entrance Scholarship Examination is taken in the second Form VI year, but bursaries for University study are available to all pupils with an Entrance qualification or better.

Primary Schools

Since 1954 a Nature Study Syllabus has been in operation in all primary schools. The work is done throughout the schools by class teachers who rarely have any science training beyond what they have received at Teacher's Training Colleges. Teachers are assisted by itinerant specialist instructors.

Some four or five years ago it was decided by the Department of Education that a wholly biological approach for all primary school science was unbalanced. This was particularly so for pupils in Forms I and II (aged 11 and 12). Since that time teachers have been encouraged to introduce work on the physical sciences in Forms I and II. Teachers' College programme have been adapted and many in-service courses held. Experiments with specific units of work have been conducted in schools and these are now crystallising into a new science programme for primary schools.

A General Science Curriculum Revision Group has recently been formed to produce a general science programme for primary and secondary schools, with particular emphasis on the Forms I to IV areas.

Secondary Schools

A standard pattern of science courses in all secondary schools, both state and independent, was introduced in 1945. Pupils are required to take a basic course in General Science, the syllabus of which is sufficiently broad to permit different approaches in schools or within a particular school for different types of pupils. The syllabus has not been changed since 1945, but the treatment in schools has shown some advance. (This is the basic syllabus which is to be revised now along with the primary school syllabus).

Science teaching in secondary schools, which has been traditionally on the English pattern, is largely directed towards the examination taken at the end of Form V,

Paper presented at the Commonwealth Conference on the Teaching of Science in Schools, held in Peradeniya, Ceylon, in December, 1963.

Form VI B and Form VI A. The School Certificate Examination (Form V) has the following major science options: General Science (Chemistry and Biology with a choice of Physics or Nutrition), Chemistry, Physics, Biology. Of the 35,000 candidates for the November 1963 examination about 15,000 are offering General Science, 11,000 Biology, 5,000 Chemistry and 3,500 Physics. (Many candidates offer two of the options). For University Entrance and Scholarship the science options are Chemistry, Physics, Biology only

All secondary schools have a number of science laboratories and the normal time allocation to science options in each form is five or six periods per week (each 40 or 45 minutes). About one-third of the time is devoted to practical work

Minor changes in prescriptions for the examination at the three levels have been made over the years; but the opinion of teachers generally is that the prescriptions are very much out of date There has been a growing tendency in all forms to introduce ideas from modern American texts and in the V Form, and more so, in the VI Form some American texts are being used by pupils. Many teachers have experimented with new American courses.

The first major change in school science courses was made in 1961 when two American Professors with an intimate knowledge of the PSSC Physics course were brought to New Zealand to conduct a concentrated 4-weeks in-service course for a group of experienced physics teachers Following this course, the New Zealand Department of Education purchased sufficient textbooks, teachers' guides, equipment and films to allow PSSC Physics to start in the VI B (University Entrance) classes of 12 schools in February, 1962 Special arrangements were made with the Universities Entrance Board for the examining of pupils following this course Since that time the majority of Form VI physics teachers have been through a PSSC in-service course and about 80 per cent of schools will use the new course in 1964.

The New Zealand physics teacher has not accepted the PSSC course as the complete answer An evaluation committee of teachers and University staff has been working since 1961 on modifications of the course to suit New Zealand conditions. Principal modifications have been made in Part 4 The evaluation committee has also been working on the problem of suitable Physics course before and after the VI B (PSSC) year. The New Zealand pupil will have done some Physics in his Forms III, IV and V years either in General Science or in the School Certificate Physics option and he may be carrying on to Scholarship Physics in Form VI A. The American one-year course does not suit this pattern.

While teachers are convinced that PSSC Physics, with its stress on fundamental concepts, has put new life into school Physics teaching, they are not committed irrevocably to this American course. Further modifications will be made. Teachers generally would be most interested in a British Physics course, but adapted for a three or four year secondary school course.

Chemistry has always been the major separate science in New Zealand schools. At its final point in schools (Form VI A) Chemistry teaching is of high standard.

Teachers are well equipped academically to have endeavoured to keep themselves abreast of modern developments in approach and content. Because British advances have in general been thought to be overcautious and conservative, there has been a strong tendency in recent years to turn to the United States. During the last two years, a number of teachers have experimented with both the CBA and CHEM study courses. In September 1963, the Department of Education convened a meeting of University and School Chemistry teachers to examine all available new material from the United Kingdom and the United States. The recommendation of the meeting was that the CHEM study programme should be tried out in full in a limited number of New Zealand schools in 1964. This recommendation has been agreed to and arrangements have been made for a special University Entrance Examination on this course. The work done in the selected schools will be studied by University and school staffs and by the Department of Education.

Biology is part of the General Science for all secondary pupils and is also an increasingly popular science option for public examinations in Forms V and VI. Although English texts are used almost exclusively, New Zealand teachers have been active in producing short texts and teaching material of their own. These are based on indigenous material and reflect also the very great interest in local ecological studies. Many teachers have had access to the American BSCS material and this has aroused considerable interest. The Department of Education brought together university and school biology experts in September 1963 to survey available material and make recommendations on the main lines of future development. This conference decided that there was great merit in the approach of overseas school biology courses, particularly BSCS, but recommended the production of an entirely New Zealand course. Steps are now being taken to second experienced university and school staff members to undertake the work.

Young folks corner

Scientists You Should Know

LINUS CARL PAULING (1901 —)

ABOLITION of nuclear weapons is perhaps the wise view of all elder-statesmen as well as peace loving people all over the world today. It may surprise a few that such a view should come from a scientist because, scientists are now generally held responsible for the creation of a period of tension and danger. When Linus Carl Pauling, Professor of Chemistry at the California Institute of Technology was awarded the Nobel Peace Prize for the year 1962, for his efforts towards banning the nuclear tests this amazement grew still more.

The new powers that science and technology have put into our hands can be abused thus bringing about chaos and destruction. On the other hand, these unlimited sources of power have also increased our capacity to shape our lives for good. Actually the present is a period of testing Professor Pauling responded to the call of his inner conscience and revolted against the present nuclear race which threatens to ruin completely the future of mankind. He had been awarded earlier the Nobel Prize for Chemistry in the year 1954 for his epoch making discoveries in the field of chemical bonds and electro-chemical theory of valency. Thus, Pauling along with Madame Curie shares the unique distinction of being awarded the Nobel Prize twice But he is the first individual to be awarded two undivided Nobel Prizes. Perhaps a coincidence of great value is the date of announcement of the award, i.e , October 10, 1963, the day on which the three atomic powers America, England and Russia signed the Moscow Treaty for banning nuclear weapons

Linus Carl Pauling

Linus Carl Pauling was born in Portland, Oregon, on February 28, 1901. By descent he is both German and British and is the son of a druggist. He graduated from the Oregon State College in 1922 and obtained the Ph.D. degree from the California Institute of Technology in 1925. He then began his intensive research into molecular structure and the nature of the mysterious chemical bond, the forces that join atoms together to form simple and extremely complex molecules. Later he did his post-doctorate work in Munich, Zurich and Copenhagen with the greatest scientists of the day like Arnold Sommerfield, Niels Bohr and others. It was at the time of his return from this European tour that he was appointed a Professor at the age of 30 and he succeeded to the Chair of his teacher Arthur A. Noyes in 1936. He married Ava Helen Miller of Oregon in 1922 He and his wife have four children and eleven grand-children.

Most of his scientific work has dealt in one way or another with the nature of chemical bond. In his papers he has discussed the various types of electron-bond mechanisms, and applied the electron theory to the structure of molecules, crystals and solid materials. His ideas gave to the scientific world a fuller picture of the structure of molecules than it had ever before According to a fellow scientist, 'Pauling's papers on the nature of the chemical bond and of resonance have altered even the language of structural organic chemistry'. These clear-cut ideas laid the foundation of a new development in industrial chemistry, viz., the production of synthetic fibres, synthetic rubber, plastics, and other comparable 'man-made' materials. These also formed the basis for his well-known book, *Nature of the Chemical Bond* (for which he was awarded Nobel Prize in Chemistry in 1954).

In more recent years his interest has changed and he has vigorously studied the structure of antibodies and the nature of serological systems. The characteristics of the protein molecule which forms the foundation of both animal and plant cell, fascinated him and he feels that 'the foundation has been laid for men to make a penetrating attack on the nature of life itself'. He has also studied the role of abnormal molecules in causing disease, especially abnormal haemoglobins in relation to sickle-cell anaemia and other hereditary haemolytic anaemias, and abnormal enzymes in relation to mental disease

In 1948 he wrote (about himself), 'I was a physical chemist with a dominating interest in the forces which cause atoms to join into molecules and molecules to react with one another. Later I tested haemoglobin, which gives the blood cells their red colour and has a large molecule. I found that in the arterial blood the haemoglobin was repelled by a magnet, but in the veinous blood it was attracted'. This led to the study of the chemical bond between the haemoglobin and oxygen. In collaboration with A E. Mirsky he produced a joint study in this regard.

This paper attracted the attention of Karl Landsteiner, the discoveror of blood types, who asked Dr. Pauling if his theory of chemical bonds could throw light on a certain antibody reaction. Thus, with the friendship of both, the study of immunology began. Pauling said, 'I gave a great deal of thought to the chemical aspect of immunology, trying to understand, in terms of the chemical

bond, how an antibody neutralizes a virus or other antigen.' By 1939 he had arrived at a chemical picture of the reaction and reported his results to the American Chemical Society as 'A theory of the structure and process of formation of antibodies'.

During the years 1939-1945 he was the official investigator for the projects of National Research Committee on Medical Research and the Office of Scientific Research and Development. However, he became a controversial figure in 1955, as the leading professional scientific critic of the American nuclear deterrent policy, forcibly setting out his views in 'No More War' (1958)

It will be now clear why the atom bombs haunt Professor Pauling so acutely. He is one who clearly understands the mighty power of an atom bomb and the colossal loss which it causes to humanity. It was this urge which made him resign from the Chairmanship of Division of Chemical Engineering of the California Institute of Technology in 1958. He has his own convictions and sticks to them unwavered. A good example of this courage of conviction is his daring statement before a political gathering where he said, 'The problem of atomic war should not be confused by minor problems like communism versus capitalism'.

Sixteen universities all over the world, have honoured him by awarding honorary degrees of Doctor of Science. The Royal Society of London not only made him a foreign member but presented him with the Davy Medal in the year 1947. He was George Eastman Professor of Chemistry at Oxford University in 1948 and visiting professor for short periods at various other universities. He is an honorary member of the Academies of Science of France, Norway, the U.S.S.R., India, Italy, Belgium, Portugal and several other countries. His contributions to chemistry and medicine have been recognized by several awards of medals.

G.S. PALIWAL.

Test Your Knowledge

What kind of plants turn to coal?

More than 3,000 species of land plants (including fresh-water and stagnant water species) have been identified from coal beds of the Carboniferous—the Mississippian and Pennsylvanian periods of the Palaeozoic era—the Age of Coal. None of them grew in salt water. There seem to be no essential differences among these plants in regard to the various ranks of coal; furthermore, they are not too much different from the vascular vegetation (dominantly conifers) growing at the present time in peat-forming swamps. During the Carboniferous era, however, they rose to astounding sizes. Ferns stood like 50-feet trees, and rushes, such as *Calamites*, with its jointed stalks, grew 100 feet tall. Lycopods, which today are small shrubs known as clubmosses, also reached 100 feet above the ground. *Lepidodendron* and *Sigillaria* are so-called scale trees, with distinctive scars marking the places where the leaves were attached to the branches.

Are birds able to think at all?

Scientists believe most bird behaviour is the result of instinctive reaction. Nevertheless, it appears that birds do depart occasionally from the instinctive pattern and act in a way that indicates a certain amount of reasoning. The fact that herring gulls take advantage of cement highways and parking fields when they drop clams on them, thus breaking them open, is frequently cited in this respect. It has been observed that an American egret at Lake Eola in Orlando, Florida, takes note of the fact that bread thrown to the ducks attracts fish. The egret repeatedly picked up bread dropped on the shore and put it in the water. It then watched intently until fish nibbled at the bread, whereupon the egret speared the fish.

Why are birds not electrocuted when they perch on high-tension wires?

If electricity were to harm a living creature, there must be a ground. Wires strung along poles pass over glass or other insulating material which prevents the electricity from being grounded at the pole. When a bird perches on a high-tension wire there is no ground, therefore the bird is unharmed. However, if the bird perched close enough so that some part of its body touched the pole or another exposed wire, it would be electrocuted, for, then a ground or circuit would be made.

Does breathing begin early in embryonic life?

Breathing does not begin until a day or two before hatching. The chick bursts the sheath that surrounds it and pushes its bill into the air chamber which at that time occupies about $\frac{1}{4}$ of the space within the egg. At once breathing begins. This is accompanied by a sharp rise in combustion, which in turn causes an abrupt drop in weight.

Why don't birds fall from their perches when asleep?

The grip of a bird is tightened by an arrangement of tendons so that the foot is not relaxed in sleep. As the bird sinks into a resting position, the large flexor tendons in the toes are stretched in such

a way that the toes are automatically pulled inward, making the grip ever tighter.

When a bird is in sleeping position, it lays its head on its back, so that it is supported without muscular effort. Perfectly balanced and with the tendons pulling the tips of the toes inward, a bird sleeps safely, even though a high wind shakes its perch.

Is the moon actually silvery in colour ?

Various tests of the light reflected from the surface of the Moon compared with light reflected from a variety of substances found on the Earth show that the light from the Moon is most like that reflected from sandstone, that is, a brownish gray in color. Actually, the Moon is one of the poorest reflectors of light in the solar system.

How do we know the temperature of a star ?

An instrument called a thermocouple indicates the amount of radiation we receive from a star. If the star's distance is known, its real temperature can be calculated. The spectroscope will tell us of the behaviour of the atoms that make up a star, and laboratory experiments give us a criterion for the behaviour of atoms of various elements at various temperatures. It is possible to estimate very closely the temperature of any star whose spectrum can be studied.

Why should you not drink seawater ?

Because seawater is so saltish that it takes more water from you than you can get from it, so that you are left worse off than before. The blood of land and fresh water animals, including our own, has much less salt than the sea, possibly because the sea has continued to get saltier since the time our anestors originally left it, which was at least some hundred million years ago.

What causes the tide ?

The attractive force of the moon, primarily, and to a lesser extent that of the sun as well. As the earth rotates, each section of the watery envelope which is the sea comes to be in line with the moon's pull approximately twice a day. In consequence a pulse or wave is set going which we call the tide. It starts where the water is deepest and where there is least land to interfere, which is somewhere in the Southwest Pacific Ocean. From there the tidal wave travels west through the Indian Ocean and passes north through the Atlantic into the Arctic seas It also moves from the center of origin east and north across the Pacific.

How often does the tide rise and fall in a day ?

Where the moon tide is the predominant tide, as it is throughout the North and South Atlantic Ocean, the tide rises and falls twice in every twenty-four hours. The Pacific Coast tides, however, are more complex, although for most of the Pacific Coast there are still two tides a day. In the Gulf of Mexico there is but one small tide a day.

Science notes

CAN MEMORY BE CONDITIONED BY CHEMICALS ?

CAN you explain the phenomenon of memorizing? Previously the mechanism of memory was attributed to the physical relationship of the nerves. The present theory is that memory might be based on biochemical process. Research on this aspect was started by Heyden, a Swedish scientist in 1950 and it is now being carried on in many other countries. All these experiments interpret the phenomenon of memorization in a new way. It has been observed by workers in the University of Michigan that in mice, some kinds of learning depend upon the animals' speed in synthesizing ribonucleic acid (RNA). They found that the time required for a learning process can be shortened or lengthened according to the slowing down or speeding up of RNA synthesis. Still, how the nervous impulses modify the arrangement of nitrogenous bases in RNA is unknown. Walter investigated the influence of emotions on the learning process. A permanent memorization needs a certain time to stabilize. What is learnt when one is emotionally affected is scarcely remembered immediatey afterwards. But it can be remembered after a certain lapse of time, a week for instance. Experiments with animals have shown that learning and memory are transferable from one flat worm to another by the use of body chemicals, including RNA.

S.D.

INFRA-RED TV CAMERA DETECTS INVISIBLE, LIQUID HYDROGEN FIRES

Formerly invisible, fires of liquid hydrogen, increasingly used as a space-rocket fuel, can now be seen with special detection equipment developed in the United States.

The system is expected to add considerably to the safe use of the powerful, volatile hydrogen which until a few years ago was considered too hazardous as a rocket fuel.

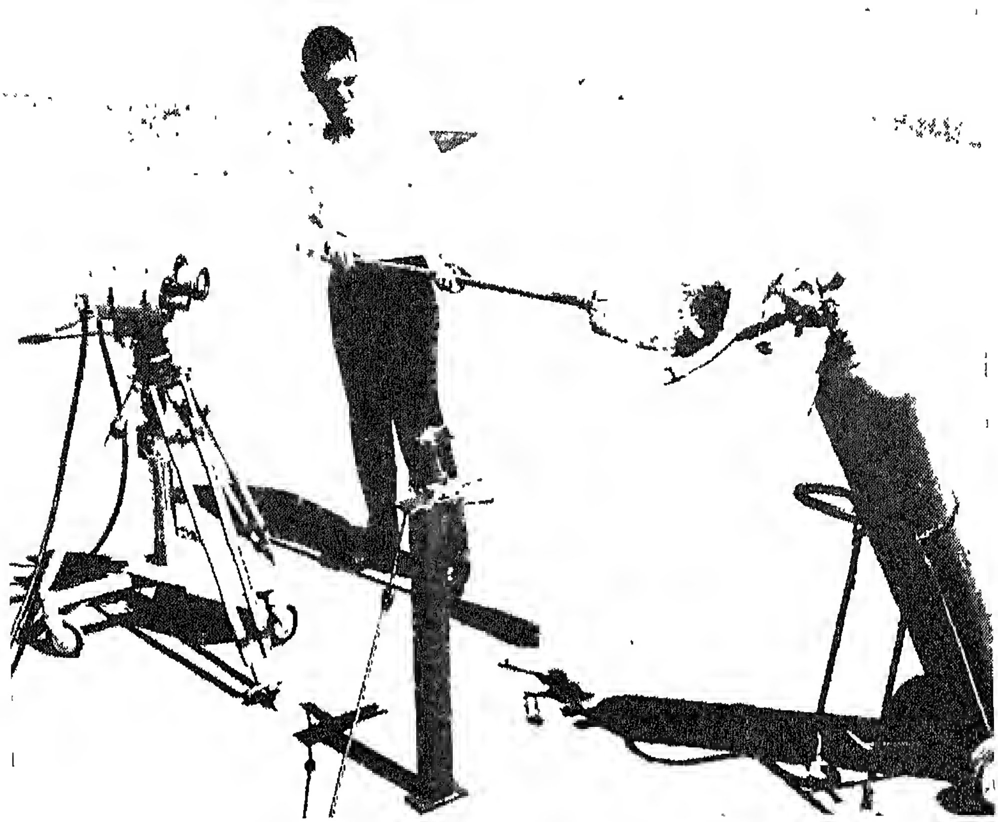
The fire-warning system consists of two small television cameras mounted side-by-side so that both cover the same field of view. One camera shows the scene in a normal way.

The second camera, however, has a special lens which filters out normally visible light and allows only infra-red radiation waves to enter the camera. The infra-red picture reveals any hydrogen fire, but no other aspect of the scene

In operation, the picture from the two cameras are superimposed on each other so that the viewer can see any hydrogen fire at its exact location in the scene.

The system was developed after two years of research and testing by General Dynamics/Astronautics at San Diego, California.

The development is significant because it will add to the advantages of liquid hydrogen which provides about 40 per cent more energy per pound of propellant than conventional kerosene-type-rocket propellants. But, besides burning with invisible flames, liquid hydrogen is



Detecting liquid hydrogen fires. Old method of searching with a broom. New method with a camera at the left

colourless and odourless unless impurities are present.

The new fire-detection system can be employed at hydrogen test facilities, at launch complexes for hydrogen-fuel rockets and for airborne surveillance aboard space vehicles.

RESEARCHERS STUDY USE OF LASER LIGHT AGAINST CANCER

San Francisco, California: American researchers report use of a powerful laser light beam to arrest cancers in hamsters.

In the highly preliminary laboratory experiment, various types of cancer planted in the cheek pouches of hamsters grew smaller and the type seemed to disappear a number of days after treatment with the intense light ray.

A team of doctors from the Tufts-New England Medical Centre in Boston and the Raytheon Company of Wayland, Massachusetts, made the report to the American College of Surgeons meeting here

They termed the experiment 'promising' but cautioned, 'we cannot claim laser treatment to constitute a cure for cancer in human patients at this time.'

Officials of the College of Surgeons called the experiment 'interesting.'

Lasers have previously been used

experimentally in delicate eye surgery to correct retinal defects.

The New England group used a ruby laser, in which a brief pulse of bright red light is produced

They aimed the light beam, lasting only a tiny fraction of a second, at the tumours. There was no immediate effect on the tumours other than a tiny burned spot After several days, however, one type of cancer appeared to grow smaller and another type seemed to disappear altogether

NEW DEVICE PERMITS MICROSCOPIC EXAMINATIONS OF INNER TISSUES WITHOUT INCISION

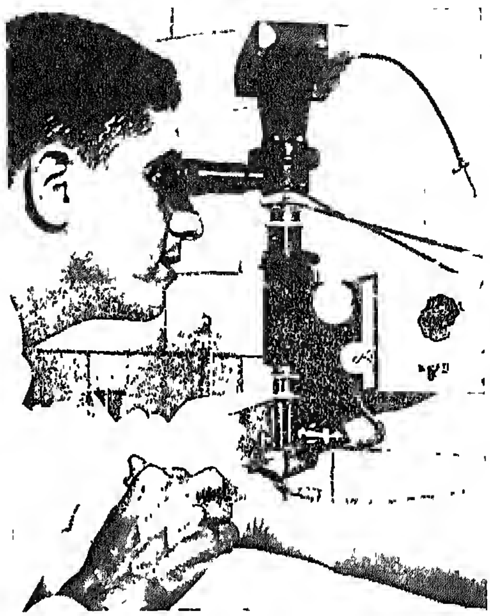
A United States physician has invented a device which permits microscopic examinations of living flesh inside a patient without an incision or removal of flesh

The invention is known as a 'hypodermic microscope' because it links a microscope with a standard size hypodermic needle of the type used to inject medicines. The device permits a physician to look beneath the skin inside the human body through the hypodermic needle.

The inventor is Dr. Charles Long Associate Professor of Physical Medicine and Rehabilitation at Western Reserve University School of Medicine, Cleveland, Ohio

On a grant from the U.S. National Institute of Neurological Diseases and Blindness, Dr Long consulted two optical scientists, Donald A. Pontarelli and Anatoli Brushenko of the Illinois Institute of Technology's Research Institute in Chicago.

The scientists spent several months experimenting with tentative designs. The heart of the new device is a pair of tiny bundles containing 10,000 glass fibres,



Device that permits direct microscopic observation of living structure

so small that they fit inside the needle One bundle carries light into the patient. The other bundle picks up the light that is reflected from the tissue under study and carries that light back to the microscope which is attached to the needle. The image is magnified by and viewed through the microscope

In the past, microscopic subsurface examinations of anatomical structures required a biopsy, that is, surgical removal of a piece of flesh from the patient.

The device permits on-the-spot observations of blood vessels and other anatomical structures in the living state. Normal and abnormal changes in these structures and changes caused by drugs can be observed for diagnosis and research.

A camera attachment makes possible a permanent record of the findings.

AGES OF STARS CAN BE MEASURED BY NEW TECHNIQUE

The ages of stars can be measured by a new lithium-counting technique developed by astronomers at the University of California's Lick Observatory.

The technique is based on the fact that young stars are rich in the element of lithium, the lightest of all metals. As a star ages it casts off lithium at a relatively steady rate.

Astronomers use a telescope to focus the light from the star they want to measure and then spread that light into a rainbow-like spectrum. They photograph this spectrum whose dark lines represent chemical elements including a line for lithium which can then be analyzed.

The new method may help bring new knowledge about the origin of stars including the sun.

By courtesy. United States Information Service, New Delhi.

ELECTRONIC FLOOD WARNER

The first flood warning given by an electronic system recently installed in the Macleay River Valley on the north coast of New South Wales, Australia, proved highly accurate.

A flood in the area during the first week of March was accurately foretold 27 hours before it arrived. Then, eight hours before it was due, the system modified its forecast to say that the flood would reach a height of 15 ft. 6 in. and would arrive at midnight. The actual height of the flood was 15 ft. 5 in. at 1 A.M.

Known as the Radio Reporting Rain Gauge System, it is the first to operate in Australia. It was installed for the Federal Bureau of Meteorology by Telecommunication Company of Australia, a division of Philips Electrical Industries.

The system is fully automatic, and enables weathermen at a recording centre in the coastal town of Coffs Harbour to obtain accurate, up-to-the-minute information on rainfall in areas up to 100 miles away.

Radio reporting units have been set up at three remote points in the uninhabited river catchment area. The units consist of tilting bucket gauges which feed rainfall information to electronic data storage and radio equipment housed in small weather-proof metal cabinets.

From the Coffs Harbour centre, the gauges are interrogated automatically at the flick of a switch. Normally, they are interrogated every three hours but if necessary can be checked every hour.

Each gauge transmits its identification and coded details of rainfall to the centre. The information is received, printed automatically, on strip paper similar to 'ticker tape'.

The system can be used also in a two-way radio telephone role, allowing maintenance men and others in radio-equipped vehicles to keep in touch with the centre.

By courtesy: Australian High Commission, New Delhi

HORMONES MAY OFFER NEW HOPE FOR LOCUST CONTROL

Research now in its early stage at the Anti-Locust Research Centre in London may lead eventually to more subtle ways of controlling locusts than the use of insecticides.

Attempts are being made to assess the possibility of interfering with locust behaviour by means of hormones. These are secretions from body glands which influence physiological action. The in-

vestigations have as their long-term aim the development of substances that might, for example, change locusts from being extremely gregarious creatures into solitary ones.

Hormone substances might also be found that prevent the insects from maturing.

The Anti-Locust Research Centre has recently moved to new premises in Kensington, London, from where it co-ordinates information on locust movements and breeding from some 40 countries, undertakes scientific research into the life history and habits of the different locust species, and investigates and develops methods for their control and destruction.

The Centre's Desert Locust Information Service issues every month a summary of the desert locust situation and a forecast of expected developments so that countries vulnerable to locust plagues can take suitable action

The Centre is administered and financed by Britain's Department of Technical Co-operation, with contributions from the United Nations Food and Agriculture Organization (FAO).

SCIENCE LESSONS FOR ALL CHILDREN IN COMMONWEALTH RECOMMENDED

Science lessons for all boys and girls in Commonwealth countries is recommended in the report of the Commonwealth Conference of experts on the teaching of science in schools which was held in Ceylon last December. Seventy delegates from 15 countries took part in the conference.

The report is issued by the Commonwealth Education Liaison Committee, which had proposed the meeting following a recommendation of the second Commonwealth Education Conference held in New Delhi in Janauary 1962.

The Ceylon conference gave a great deal of thought to the use of science education as a factor in reducing the gap between the developed and developing countries. Recommending science for all, it argued that the economic and social advances which technological development makes possible may not be achieved unless ordinary people see the sense of what is being done.

The report says that the beginnings of a study of science in schools should be made at the stage of primary education. It discusses the needs of abler students, including not only those who will make their careers in science and technology but also those who will be leaders in other fields for whom an understanding of science is no less important.

The conference took note of the almost universal shortage of science teachers. As a quick means of augmenting the science teaching force in countries where the need is specially great, it recommends an abbreviated training course of about a year's duration, which is envisaged as a temporary expedient only.

A pooling of resources on a regional or an even wider basis would help to establish institutions for research and development in science education which would design courses, assist in the evaluation and assessment of science teaching, devise teacher-training programmes, develop apparatus, study the uses of teaching aids and disseminate information. They might serve as bases for experts whose services could be made available to countries needing them.

By courtesy : British Information Services, New Delhi.

New trends in science education

Summer Institute Programme

The sixteen Summer Institutes announced earlier started working from June 8, 1964 and will last till July 15. They all aim to achieve the following objectives:

(*i*) to establish channels of communication between schools and universities,

(*ii*) to improve the subject matter competence of participating teachers, by acquainting them with recent developments in their subjects;

(*iii*) to enable teachers to develop a better understanding of the basic concepts in their field of specialisation;

(*iv*) to enable teachers to conduct experiments, wherever possible, and with simple and improvised apparatus, and to encourage further experimentation along suggested lines leading to a consideration of theoretical ideas growing from experiment;

(*v*) to strengthen the capacity of the teachers for motivating able students to develop an aptitude for research;

(*vi*) to stimulate interest in teachers by bringing them into contact with eminent men in the field of their study, and

(*vii*) to enable teachers exchange views with their colleagues in the profession and thus promote a greater understanding and appreciation of each other's teaching problems.

The names of the academic staff and the visiting scientists of the Institutes are given below.

BIOLOGY INSTITUTES

BOMBAY UNIVERSITY, INSTITUTE OF SCIENCE, BOMBAY

Academic Staff

Dr. D.V. Bal
Dr. N.B Inamdar
Mr. P.J. Dubhash

Visiting Scientists

Dr. Walt Auffenberg,
Department of Biology,
University of Florida,
Gainesville, Florida, USA.

Mr. Manert H. Kennedy,
Science Teacher,
Fraser Public School,
Fraser, Michigan, USA.

DELHI UNIVERSITY, DEPARTMENT OF BOTANY, DELHI

Academic Staff

Dr. B.M. Johri
Dr P.S. Sabharwal
Shri P.Y. Rajamannar

Visiting Scientists

Dr Wilson N. Stewart,
Professor of Botany,
University of Illinois,
Urbana, Ill USA.

Mr. Phillip R. Fordyce,
Assistant Professor of Science Education,
Florida State University,
Florida, USA.

MADRAS UNIVERSITY CENTRE, MADURAI : DEPARTMENT OF ZOOLOGY

Academic Staff

Prof. S. Krishnaswamy
Prof. J C.B. Abraham
Dr. R. Kalyanasundaram

Visiting Scientists

Dr. Edwin A. Phillips,
Professor of Botany,
Pomono College,
Claremont, California, USA.

Mr. Dempsey L Thomas,
Teacher in Biology,
Board of Public Instruction,
Sarasota, Florida, USA.

UTKAL UNIVERSITY RAVENSHAW COLLEGE, CUTTACK

Academic Staff

Dr. B. Samantrai,
Dr. B.K. Behura
Dr. G Mishra

Visiting Scientists

Dr G.R. Noggle,
Professor and Head of the
Department of Biology,
University of Flordia,
Florida, USA.

Dr. Leonard Winter,
Professor of Biology,
State College of Iowa,
Ceder Falls, Iowa. USA.

CHEMISTRY INSTITUTES

RAJASTHAN UNIVERSITY, JAIPUR . MAHARAJA'S COLLEGE, JAIPUR

Academic Staff

Prof R.C. Mehrotra
Dr. J.P Tandon
Dr. R.L Mittal

Visiting Scientists

Dr. Gordon Lee Hiebert,
Associate Professor of Chemistry,
Bowdoin College,
Brunswick,
Maine, USA.

Mr. Merrill M Merritt,
Teacher in Chemistry,
School District No 1,
Multnomah Country,
631 Northeast Clackmes Street,
Portland.
Oregon, USA.

POONA UNIVERSITY, POONA . DEPARTMENT OF CHEMISTRY

Academic Staff

Dr. V.K. Phansalkar
Dr. A.J Mukhedkar

Visiting Scientists

Dr John L. Biester,
Associate Professor of Chemistry,
Beloit College,
Beloit, Wisconsin, USA

Mr. Raymond T. Byrne,
Head of Science Department,
City School District,
City of Batavia,
Batavia, New York, USA.

BURDWAN UNIVERSITY, BURDWAN : DEPARTMENT OF CHEMISTRY

Academic Staff

Prof. S.K. Siddhanta
Dr. S.C. Rakshit

Dr. R.L. Dutta
Dr. S. Ghosh Majumdar

Visiting Scientists

Dr. Gerald A. Edwards,
Professor and Chairman,
Department of Chemistry,
The Agricultural and Technical
College of North Carolina, USA.

Dr. James V. DeRose,
Head of Science Department,
Marple-Newtown School District,
Newtown Square Penn. USA.

OSMANIA UNIVERSITY, HYDERABAD : COLLEGE OF TECHNOLOGY

Academic Staff

Prof N.V Subba Rao
Dr. V R Srinivasan
Mr. Venkobacharya Upadhyaya

Visiting Scientists

Dr. Milton Temres,
Professor of Chemistry,
University of Michigan,
Michigan, USA.

Mr. Kenneth V. Fast,
Teacher in Chemistry,
Board of Education,
Webster Groves,
Missouri, USA.

PHYSICS INSTITUTES

BANARAS HINDU UNIVERSITY, VARANASI
COLLEGE OF SCIENCE : DEPARTMENT OF PHYSICS

Academic Staff

Professor A. R. Verma
Dr. G.K. Das
Dr. V.S. Mathur

Visiting Scientists

Dr. Kenneth C. Clark,
Professor,
Department of Physics,
University of Washington, USA

Mr. Bryan F Swan,
Teacher of Physics,
University of Chicago,
Laboratory School,
Chicago, USA.

GUJARAT UNIVERSITY, AHMEDABAD: DEPARTMENT OF PHYSICS

Academic Staff

Dr Y.G. Naik
Dr. K.B. Shah
Shri C.A. Pathak

Visiting Scientists

Dr. David Kenneth Baker,
Professor of Physics,
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Mr. Coleman Monroe Loyd,
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Prof. David M. Alexander,
Instructor in Physics,
Foothill College,
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Shri Mohan Lal
Dr. C. Mohan
Shri H.K.L. Vasudeva

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Mr. Peter David Mandell Perente,
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Mr. C.C. Shah
Mr M.H. Vasavada

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Mr. Shirley E. Boselly, Jr.
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Dr Oscar Frederick Schaff,
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NORTH BENGAL UNIVERSITY, RAJA RAMMOHUNPUR· SNOW VIEW HOTEL, DARJEELING

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Assessment of Summer Institutes of 1963

N.E. Bingham and I.C. Menon
Summer Institute Administration Unit,
New Delhi

THE Summer Institute Administration Unit has received a number of letters from participants of the 1963 Summer Institutes, which reveal the extent to which these Institutes have been useful in improving Science Education in schools and how the participants have been able to modify or improve their practices. Extracts from the letters are given below. It is assumed that the information found here will be useful to other teachers.

From Biology Teachers

BHOPAL: I have tried successfully, a number of experiments, particularly 1. Cells as Robert Hooke first saw them. 2. Living plant cells—onion epidermis. 3. Living plant cells—stomata of Tradescantia. 4. Yeast culture. 5. Bread mould. 6. Bacteria in root nodules. 7. Movement of chloroplasts—Hydrilla. 8. Blood of the frog. 9. Animal population in a fresh water pond. 10. Fresh water algae. 11. Circulation of blood in the web of the frog's foot. 12. Study of animal cells.

I have observed that no student of mine felt any difficulty in performing and understanding the above experiments. Although these experiments were not included in their course of study, and were quite new to them, they found them fascinating and most of the students insisted on repeating these experiments.

I believe if the materials, chemicals and other equipment, are available in higher secondary school laboratories, there will be no difficulty in practising all the experiments given in the Yellow Version of the BSCS programme.

I am trying to spread all the knowledge that I have gained in the Madras Summer Institute 1963, by starting an "exchange of biology teaching programme". Almost all the biology teachers of the city are co-operating. By now, under this scheme, I have delivered two lectures at two different schools. Three different lectures are scheduled to be given in the near future by other teachers of the city.

Of the many experiments attempted in the classes the following aroused the interest of the pupils the most: 1. Chloroplasts in living cells of Hydrilla plant, 2. Bread mould, 3. Pond life, 4. Blood typing, 5. Fungus grown on agar culture, 6. Amoeboid movements of mercury drops in potassium dichromate and nitric acid.

Of all the teaching techniques, the best and the one most liked by the students was the use of "Invitations to Enquiry." This method was tried with the 9th and 10th classes in particular. It promotes thinking scientifically and stimulates intelligent answering. It rouses the interest

of the students more effectively than other methods. I wish we could have 'Invitations to Enquiry' for all of our Biology lessons

These activities help the children to develop scientific minds Eagerness and curiosity are aroused in them, but the chief difficulty is lack of time, which limits the work that can be done in class. He has been able to perform, in his school the following practical experiments, which he learned in the Institute:

1. Experiment with potato cores.
2. Cells—onion and cork.
3. Stomata and a section of leaf.
4. Test for starch.
5. Three, four functions of leaf—transpiration, photosynthesis, respiration (The children were very much excited and interested in these experiments.)
6. Chromatography. (The separation of colours in this experiment made them very happy and all tried to do it again and again.)
7. Parasites in plants and animals.
8. Germination and growth of bean seeds
9. Organisms in water
10. Spontaneous generation.
11. Circulation of blood in the tail fin of gold fish. (Very easy for students to do the experiments.)
12. Stages in life history of the frog.
13. Examination of blood under microscope—kinds of corpuscles
14. Blood typing.

KANPUR: A teacher from an Intermediate College writes at length about the experiments and other innovations that he has made inspite of his busy routine of covering the prescribed conventional course of the U.P. Board of High School and Intermediate examinations. 1 The first experiment which I tried was a demonstration of the amoeboid action of mercury in the presence of potassium dichromate and nitric acid. Students took a keen interest and were overjoyed to see this activity. It gave them a clear picture of the effect of surface tension in such movements. 2. Some of the students were so interested in the life history of the frog that they brought tadpoles from a local pond and tried to rear them in a petri dish with tap water. But next day all the tadpoles were dead. They brought more tadpoles and tried to rear them in a petri dish with tap water, having soil and grass at the bottom. They were happy to see them surviving on the third day. Now they took a glass tub with soil at the bottom and inserted grass in it. They poured fresh water in it and finally brought fresh tadpoles to rear. Day by day they observed fish stage, two-legged stage, four-legged tail stage and finally on one fine day, after nearly three months, their joy knew no bounds when they saw a tiny, ugly, black wrinkled and tailless tetrapod frog, totally different from the swimming tadpole jumping on the wet soil. On that day I told them it was a toad whose stages of metamorphosis, were similar to that of the frog. The feature "Invitations to Enquiry" has struck me as a creative method of developing biological thoughts in the students. I was surprised to see the curiosity of a boy who actually found the developing and hatching pupa of a butterfly in the college compound. After studying the life history of a mosquito and house fly, and using the "Invitations to Enquiry", demonstrated to the students the emerging

butterfly in their natural habitat. "Invitations to Enquiry" is a wonderful part of biology teaching and more stress should be given to this approach in the teaching of the subject.

GUJARAT: Immediately after coming back from Madras, we got all the laboratory equipment needed for implementing the experiments we learnt. It is an exciting experience for both the teacher and the taught, to teach and learn through "Invitations to Enquiry". As a matter of fact, I have prepared 70 invitations, the enquiry of which, if properly brought out can easily cover all of the curriculum of biology for the secondary students. We have introduced the majority of the experiments, and all, very effectively. We have not yet encountered any difficulty in implementing the new approaches in the teaching of biology.

BIHAR: The 'Invitations to Enquiry' was tried in the 9th and 10th standards. (10th standard here, is Pre-Senior Cambridge class.) The subjects we discussed were: germination of seeds, insect pollination, pollinated flowers, and external features of a rabbit as related to its habitat. The students showed great enthusiasm. This is a very good approach to use in keeping up interest. A good percentage of the boys were able to make correct definitions wherever they were necessary. The boys from out-stations responded better than those who came from the capital city. The use of "Invitations to Enquiry" takes a lot of time in the class and requires a lot of preparation on the part of the teacher. Yet the candle is worth the game.

I also introduced a few observational experiments: external features of an insect in the 9th standard and experiments on osmosis and respiration in the 11th standard. The students were not given the slightest idea about what they were going to learn in order to keep up their curiosity. In the first case the boys collected and observed cockroaches and summarised the characteristics which they noticed. House flies were given later. They were then asked to write down a few common characters found in these two insects. Later they were asked to compare their answers with the general characteristics of insects given in their textbooks. The response was very good. The observations were made by using a hand lens. Their observations were better on the larger insects.

Many of the teacher participant respondees have complained that they cannot impart instruction with the new materials to their students because this new content and these new approaches are not in the syllabus, they have to teach.

From Chemistry Teachers

The extent to which the teacher participants in chemistry have been able to make innovations in their teaching is not unlike that of those in biology as can be judged from the following summaries of descriptions sent by three of the chemistry teachers.

TUMKUR (MYSORE STATE): Soon after returning from the Summer Institute I prepared a plan of work to introduce some of the important aspects of CHEM Study to my students. I have chosen one section of the 10th standard as an experimental group. In this experimental group I have been integrating some parts of CHEM Study with the contents of the

elective chemistry course that I have to cover for the S.S.L.C. Examination in my State.

I have successfully introduced the first six chapters and the chapters on rates of chemical reaction, atomic structure and the periodic table to my students. I am unable to introduce the chapter on chemical calculations for, that part is beyond the background of mathematics of my students and required to cover the contents of the syllabus for the examination.

In the practicals, the students are divided into small groups of three or four. Each group conducts an experiment on a specific topic chosen for the day. Then a post-laboratory discussion is held. Students explain their observations by putting forward their own hypotheses and advance arguments in support of them. This discussion helps them either to amend or alter their hypotheses and to arrive at conclusions dispassionately.

I found that I need four extra hours per week to carry on the experiments in this new approach to science teaching. I have also been applying this new approach in teaching general science classes.

BARODA: A teacher from the University Experimental school has been able to introduce this new approach and the new materials to the extent of 25 per cent even though his syllabus does not contain any of these new materials. He has found that introducing the electron transfer theory in chemistry, helps in remembering and understanding chemical equations. He has also found that discussions of certain aspects of the periodic table are helpful too. He wishes that there could be some organization of the teacher participants of these institutes to meet and exchange ideas. He states that all should meet after trying out certain aspects of the CHEM Study Materials. In this way they could discuss difficulties and successes they had in using this approach.

TUMKUR (MYSORE STATE). The CHEM Study Materials help me to make my science teaching more effective and purposeful in approach. The pre-laboratory and post-laboratory discussions have been very effective in making science learning interesting. The students are able to learn the processes of science better by offering their hypotheses and then discussing them and finally coming to conclusions.

I have been devising multiple choice questions to make evaluation more objective. The teacher's guide and achievement tests of the CHEM Study Materials have helped me to improve my science teaching.

From Physics Teachers

Considerable difficulty has been encountered by the Physics teacher participants in their attempts to apply the new approaches that they have learnt in the Physics Institute this past summer.

BIHAR: We returned from our summer institute in physics with great hopes and higher ideas as regards science teaching, and I still believe that these new methods of teaching physics excel the older methods and at the same time are more beneficial to the students. In some of the lessons on electrostatics and light, I have applied this method and our students have responded well. But the frequency of application is poor because the topics are not the same as in our present syllabus. Our present syllabus for higher secondary schools represents the major difficulty as it

is over-crowded with unnecessary topics and details that are bookish. So there is not adequate room for practicals which are so necessary for the basic concept of physical theories as well as for the development of the personality of the student as a whole.

In order to keep up the dignity of the school we care more for a larger number of our students getting through the examinations and so we adopt to some extent short-cut methods Our students also memorise important topics (from the examination point of view) without acquiring the basic concept of the theory. Hence they forget the idea very easily and reach the same point from which they first started. So our present methods of examination present a great difficulty.

In teaching the PSSC Physics the laboratory difficulty is less than in using our present syllabus The instruments are simple, low-priced and give the students a clear concept of the physical facts. But however small the price may be we cannot buy them due to certain difficulties in government offices

MADHYA PRADESH (Municipal Multipurpose Higher Secondary School) · The PSSC PROGRAMME is very ambitious but it cannot be put into practice as it is because of the rigorous external public examination system. However, I feel that the PSSC approach can, and should be introduced in some spheres of teaching. I have introduced the approach in the laboratory work. The reaction of the students is encouraging but the method requires more time. I propose to introduce it more vigorously in the next session I have organised a programme to divide the junior class into two equal halves. The first group will study theory by a supervised study plan: PSSC approach will be followed for the laboratory work. The other group will be allowed to proceed on traditional lines. It is proposed to evaluate the respective difficulties in following this method and also to determine statistically, the difference in achievement of the two groups.

ANDHRA PRADESH (Government Training College): Regarding the opportunity to follow the new approach and new materials I feel that an administrative order to follow the same, as an experimental measure, by the D.P.I. is required. If the attested syllabus is not completed by the science teacher he is considered to have not done his duty by the administrative authorities. Hence these approaches were not regularly followed, though the spirit of them was indicated to pupils in the course of regular classroom science teaching. Six items of new approach involving use of new apparatus supplied to us on the eve of our parting are being used in the science club activities to make the pupils understand the basic concepts in the modern methods of teaching physics. These are immensely liked by the pupils. It is desirable that the teachers who have been given training should be given the opportunity to use this training, freeing them from the regular routine and imposed syllabus.

ANDHRA PRADESH: We are overloaded with our regular syllabus and school work. We are finding it very difficult to cope up with the syllabus and practicals prescribed for the twelfth classes before March 1964. Moreover there are no instructions from our Government to implement our experiences in this school.

WEST BENGAL: The School authorities are obsessed with the public exami-

nation and look at any new thinking with suspicion. My duty is to prepare a note on possible questions and get them memorized by the unfortunate students by repeated class examinations. Laboratory work is almost non-existent; the school has a nice projector but has no time to use it. The school runs on a shift basis. I have become tired and restive and feel choked in this medieval climate.

I returned last July with the object of serving my own State and applying the knowledge gained in the Summer Institute and to continue to experiment with it under local conditions. I feel frustrated.

It is clear from the above comments that the physics teachers have had more difficulty than either the chemistry or the biology teachers in implementing their learnings of this past summer. Some steps must be taken to free these people to teach this new programme.

From Mathematics Teachers

The teacher participants from the Mathematics Institute had varying success in implementing the ideas of their institute in their own classrooms.

MYSORE: There is no denying the fact that mathematical content and instruction in schools is quite out-moded and needs a thorough change. The Summer Institute in Mathematics was arranged with this in view, and has done a good job of pointing out the changes needed. Though at first I was diffident about these new ideas I started appreciating them after sometime. The most outstanding outcome of the Institute was the revelation of the true nature of mathematics. It is most tragic that most of the teachers of mathematics teach mathematics in such a way that the students get an impression that mathematics means working out problems. It is the mathematical way of thinking and not the working of mathematical problems as such that a sincere mathematics teacher should aim at.

I must admit that I have not been able to disseminate many of the things I have learnt. This is because of the rigidity of the syllabus and the examination system. Furthermore, analytical geometry and trigonometry are not included in the 10th class. But my teaching has undergone a pleasant change in that whatever topic is taken for treatment it is taken in a very mathematical way and not in a mechanical way. A few examples will make this point clear.

The 8th standard general mathematics class boys, studied fractions, decimals and approximation. Instead of jumping off directly and performing various operations I told them something about the number system itself for example: integers form a set of numbers, fractions also form a set, integers, fractions and decimals all belong to a set of real numbers. A decimal is just another name for a fraction. It is a fraction with a denominator, a power of ten. Whenever a topic on numbers is taken up it is useful and interesting to tell the students something about the number system. Let the students be given a very broad outlook on numbers in general, let them realise that they are performing the operations on a particular set of numbers, for example on decimals or fractions.

Let them know that addition and subtraction, that multiplication and division are inverse operations. When this is shown by concrete examples the students are very much amused and happy.

In dealing with simple equations I have

found that the SMSG method of expression 'Seven minus two is another name for five' extremely useful. Similarly the terms 'open sentence', 'true set domain of the variable', can be used to a great advantage. These terms enhance mathematical precision, which is unfortunately ignored in traditional teaching. I have also stressed the fact that mathematical inequalities are more important and interesting than equalities.

Ideas of one-to-one correspondence in graphical treatment of equations are most useful in developing understandings.

I have not been able to implement much of the geometry learnt at the Institute. However, before beginning a formal treatment of geometry, I had made it clear that geomery is a study based on some undefined concepts and some postulates, that no geometry is absolute, that we can have different geometries based on different axioms.

The study of statistics has been a very great help. Since statistics is included in the 10th standard, the students find statistics most interesting. Even with the present syllabus there are ways and means by which we can present a very true picture of mathematics and reveal its great quality and effectiveness, and also develop the mathematical way of thinking in students.

Without any drastic change in the syllabus we must be content with making only passing references to some new ideas and so the sooner the content is changed the better it is for mathematics. It is most important that we define the objectives of teaching mathematics at the secondary stage and then reorganise our content in such a way as to suit the objectives.

UTTAR PRADESH (Intermediate College): The idea of number systems, the idea of a number of geometries and algebras have definitely helped me in my class teaching and in developing a case for mathematics among the boys, but since the new concepts have not yet been prescribed by the examining boards, they cannot be taught as regular courses. Separate meetings of the Mathematics Association in the school will help to give the students an idea of the new concepts of trigonometry, sets, and the like, but proper measures have to be taken to keep them from writing these concepts in the examinations. It has been the experience that the boys are better recipients of these new ideas than are the teachers.

There will be much saving of our resources if our training colleges are also included in our mission to extend the new mathematics. Every teacher looks upon these training colleges with a view to gaining something new. In my opinion it will not be an injustice if some of the superfluous courses there are cut down and the new concepts propagated. The pupil teachers may then be examined on these new concepts. In due course these training colleges will become permanent active centres for further implementation of the new educational schemes. They will also be helpful when we come to experiment with our new techniques in our schools. By involving the training colleges we will be able to send out better teachers and make education more effective.

KERALA: I had a pleasant experience in the Summer Institute in Delhi. I came to know about many new ideas in the new field of mathematics education, but I am extremely sorry to tell you that

I was never able to communicate these new ideas to any of my students. I am not in a position to do that. We have the prescribed syllabus before us and we are not able to spare even a minute for any digression. So unless and until the syllabus is modified according to the new scheme, I will not be able to propagate the new idea.

Summer Institutes of short duration should be conducted in every State, and these new ideas should be imparted to all teachers. People who are well-versed in the new schemes should be given preference in appointment as lecturers in training colleges, so that the future trainees may come out of the colleges with a thorough knowledge of the new approaches.

CONCLUSIONS

While many of the above comments extracted from letters written by teacher participants are most encouraging, others point out the difficulties in winning the acceptance to the new approaches. If these new approaches to the teaching of the sciences including mathematics are to take root and grow here in India, the combined efforts of university people, educators, teachers, education directors, and various district officers will be needed to make the advances so essential for the future welfare of India.

News and notes

SCIENCE TALENT SEARCH SCHEME 1963-64.

ON the basis of their performance in the theory papers, the top 1,200 students were called for interview by six different Interview Boards organized at different centres in the country. For keeping up the uniformity in the standards of scoring at the Interview Boards, the Chairmen of the different Boards were requested to come to the meeting of the Delhi Board. The following is the detailed information about the Interview Boards:

1. *Delhi Board*:
May 14 *to* 17, 1964.

Dr D.S. Kothari, *Chairman*,
University Grants Commission,
Mathura Road, New Delhi-1.

For contestants from the Territories of Delhi and the State of Rajasthan.

2. *Dehra-Dun*:
May 25 *to* 29, 1964.

Prof. N R. Dhar, *Chairman*,
Director, Shiela Dhar Institute
of Soil Sciences, Allahabad.

For contestants from the States of Uttar Pradesh and Punjab and Himachal Pradesh.

3. *Calcutta*:
May 25 *to* 28, 1964.

Prof. B.D. Nagchaudhuri, *Chairman*
Director, Saha Institute of
Nuclear Physics, Calcutta-9.

For contestants from the States of West Bengal, Orissa and Bihar.

4. *Gauhati*:
May 30, 1964.

Prof H.J. Taylor, *Chairman*,
Vice-Chancellor, Gauhati University,
Gauhati. (Assam)

For contestants from the State of Assam and Union Territories of Manipur and Tripura.

5. *Ahmedabad*:
May 25 *to* 28, 1964.

Dr. J.J. Chinoy, *Chairman*,
Professor of Botany and
Director of the School of
Science, Gujarat University,
Ahmedabad.

For contestants from the States of Madhya Pradesh, Gujarat and Maharashtra.

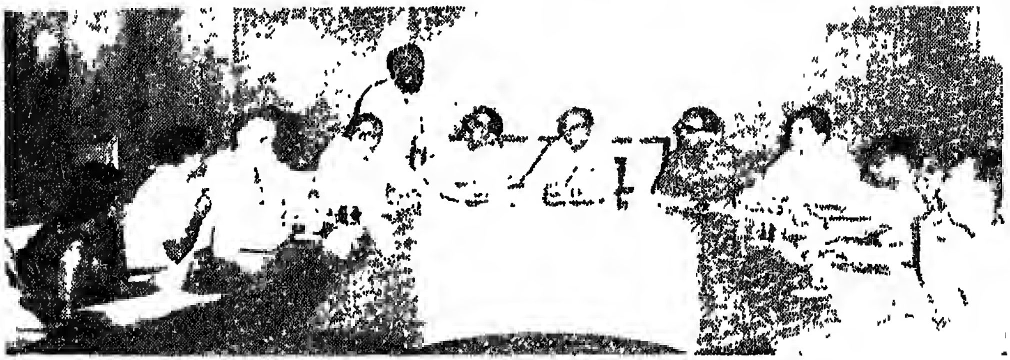
6. *Bangalore*:
May 28 *to* 31, 1964

Prof. P.L. Bhatnagar, *Chairman*,
Department of Applied Mathematics,
Indian Institute of Sciences,
Bangalore.

For contestants from the States of Madras, Mysore, Andhra Pradesh and the Territories of Pondicherry, Goa, Daman and Diu.

The chief feature of the Science Talent Search Examination of 1964 was that some of the contestants had written out-

Science Talent Search : Candidates waiting for interview at New Delhi



Interview Board with Dr. D.S Kothari, the Chairman (centre)

standing Project Reports which revealed that these students were not governed by the rigours of the curriculum and they had read a lot of literature beyond the routine type On the basis of the data available from the test, it is proposed to develop some useful research projects which will be both informative and of use to the teachers of science and to the talented students.

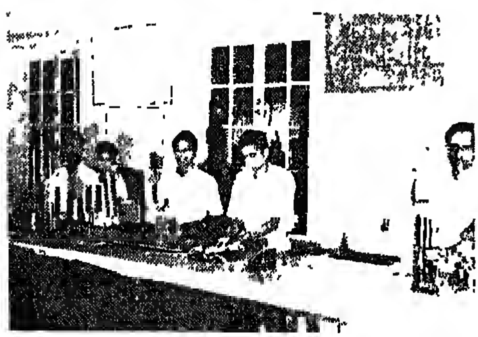
On the basis of the theory papers, the project reports and the interviews, 350 top students will be awarded scholarships for pursuing higher studies in basic sciences leading to a B.Sc. degree. The next 200 in the order of merit will get Certificates of Merit only.

SCIENCE CLUBS

The Department of Science Education has been endeavouring to energise creative activity at the school level by sponsoring the establishment of science clubs in the schools and by organizing science fairs at different levels. During the year 1963-64, 106 Science Clubs and 15 Central Science Clubs were established through grants-in-aid given by the Council. Grants for organizing 80 Science Fairs at the regional level were also given. A pilot project of State level science fair was

organized in the State of Mysore at Bangalore. The Science Fairs provided good stimulus for the activity at the school level and created healthy competition amongst students. The participation in the fairs has been steadily increasing and the interest taken by many schools has been of a high order. Projects in the field of various sciences have been organized by schools and some of them have found publicity both in India and abroad.

Science Fair, Calcutta : A student explaining the model of coal gas plant



Science Fair, Calcutta. Sound exhibits

The Department proposes during the current year to intensify its activity by establishing more Science Clubs, and by holding Science Fairs at the district level also, so that, a vast majority of the schools may get an opportunity to participate in Science Fairs.

The State level fairs are designed to enlarge the activity of these clubs by giving greater recognition to the meritorious students and encouraging schools to do better work. As a result of the success obtained in the pilot project at Bangalore, it is proposed to hold two state level science fairs this year—one at Bangalore and the other somewhere in Northern India. It is further proposed to subsidize the organization of the district level science fairs by award of small grants-in-aid for the said activity.

PREPARATION OF GENERAL SCIENCE CURRICULUM FOR HIGHER SECONDARY CLASSES

The first Regional Seminar for the drafting of General Science syllabus for classes IX, X and XI of the Higher Secondary Schools was held at the Teachers Training College, Banaras Hindu University, Varanasi, for three days, March 20–22. Prof. A.R. Verma, Head of the Physics Department, Banaras Hindu University, inaugurated the seminar.

Besides the officers of the Department of Science Education, the seminar was attended by the Professors of the Physics, Chemistry and Botany departments of the Banaras Hindu University, two lecturers of the Physics Department, one Assistant Professor of Chemistry, Allahabad University; Science Consultants from Madhya Pradesh and Delhi; Science Lecturers from Central Institute of Education and Training College, Varanasi and Science teachers from Queen's College, Varanasi.

Prof. Verma, in his inaugural speech, emphasized that science at the higher secondary level must add to the richness of life, and afford a foundation for higher education. Science is a process of doing, seeing, interpretting, etc. and as such it should help a person to discover his interests.

Mr. V N. Wanchoo read a paper on the position of General Science at the higher secondary level, in different states of India Dr. R.N. Rai explained the implications of scientific literacy as one of the aims of teaching General Science at this stage and discussed the position of increasing opportunities for school and college education, and the resources available for the improvement of science instruction The participants raised questions and discussed the importance of General Science vis-a-vis elective sciences, policy of different states regarding examination in General Science, production of suitable literature, films and other aids, demonstration of experiments, and other related aspects

After a thorough discussion on the points raised in the paper and by the participants, the following decisions were taken :

1. The proposed General Science syllabus should be taught for three years, with four periods per week.
2. It should be examined externally as other subjects are being examined.
3. The syllabus is proposed for both science as well as non-science students.
4. Same textbooks should be prepared for both science as well as non-science students.
5. Emphasis in the new textbooks based on the proposed syllabus should be on historical aspect of science as a challenge and an opportunity to revise opinion when new evidence is available. Inquisitive-news should be maintained throughout the book and dogmatism should be fought wherever there is a suitable opportunity for it.
6. In the chapters dealing with life science emphasis should be on functions and not on definitions. Difficult terms should be avoided as far as possible.
7. If it is found difficult to provide equipment for experimental work by the students, necessary demonstration apparatus should be provided to schools.

The draft syllabus was first discussed by the seminar as one group Some modifications were suggested. The group next divided itself into three sub-groups—physics, chemistry and biology—to discuss the proposed major concepts in the different subject fields and to suggest sub-concepts for each major concept The final draft emerged as a well-linked syllabus in which the items proposed under different subject fields merged to present a unified picture of science.

BIOLOGY TEXTBOOK PANEL

Further progress has been made in preparing the manuscript for the press. The first section of the book consisting of nine chapters are ready and it will be sent to the press in the first week of June 1964. The other sections will be sent as and when ready.

Books
For your science library

Radio Exploration of the Planetary System. SMITH, ALEX G and CARR THOMAS D. D. Van Nostrand Company, Inc., Princeton, New Jersey 1964. pp. 148.

THE study of astronomy began at such a remote date that it is not possible to ascertain when the ancients came to recognize the distinction between the so-called fixed stars and the planets. The ancient astronomers were very much handicapped by lack of refined instruments to make accurate observations. The telescope invented in the beginning of the seventeenth century and the photographic method of recording observations increased their power of observation to a very great extent.

The optical telescopes make use of a region of the electromagnetic radiation lying between the ultraviolet and the infrared for which the atmosphere of the earth is transparent. It was discovered in the 1920's that another region for which the earth's atmosphere is again transparent lies at much longer wavelengths, in the radiowave region. The present book gives a very readable and up-to-date account of the application of radiowaves for the study of the planetary system.

The first chapter gives a historical account of the development of the methods of radio-astronomy. Although attempts had been made at the end of the last century to discover the radiowaves emitted by the Sun, it had to wait the necessary technological advance and then it was not from the Sun that radio emission was detected first but from the direction of the centre of the Milky Way, i.e., from the centre of our own galaxy.

The second chapter describes the different instruments used by the planetary radio astronomer. The third chapter gives an account of the thermal radiation received from the Sun, the Moon and the planets and discusses how by an application of the law of black body radiation, it is possible to calculate the radio temperature of these bodies.

The fourth chapter is devoted exclusively to the study of the radio spectrum of Jupiter, and the fifth chapter discusses the origin of the planetary radio signals. The sixth chapter describes the application of radar for the study of meteors, the Moon and the planets. When Kepler formulated the laws of planetary motion, or when Romer first determined the velocity of light from the observations on the time of revolution of one of the satellites of Jupiter, the exact distance of the planets from the Sun was not known. The recent determinations of the distance of the earth from the Sun by the methods being used since the second half of the eighteenth century differ from each other by two parts in one thousand. By receiving the echoes reflected from the Venus it has been possible to determine this

distance or what is called the astronomical unit and the results obtained by different observers differ from each other by only three parts in a hundred thousand. It is hoped that in future it will be possible to determine this distance more accurately by this method.

The last chapter is devoted to the discussion of the contributions of radio astronomy to space science and other related matters. At the end of each chapter have been given references to the latest literature on the subject and there is a general bibliography at the end of the book

Although the book is primarily meant for the students of physics, any intelligent reader with some interest in science will find the book interesting and informative.

The Universe of Space. MILLMAN, PETER, M. Routledge and Kegan Paul, London. 1963, pp. 117.

THIS book gives a simplified account of the Solar System, the Sun, the stars, galaxies and systems of galaxies in a non-mathematical language. The first chapter entitled 'Man and Telescopes' gives an account of the men who have contributed most to the development of astronomy and the instruments like the photographic plate and the optical and radio-telescopes.

The second and third chapters give an account of the planets, the moon and other bodies of the solar system excluding the Sun. The idea of the rapid advances being made in the study of the heavenly bodies is given by the statements regarding the Venus. On p. 24 it is stated that 'the length of its (Venus's) day is not yet known with any certainty, but this is probably a few weeks.' It is now known that the length of Venus's day is the same as its period of revolution round the Sun, i.e., 225 days. Similarly the surface temperature of the Venus is about 425°C. and its atmosphere consists mostly of carbon dioxide at a pressure of about 10 atmospheres.

The fourth and fifth chapters are devoted to a discussion of the sun and some of the typical large and small stars Although in mass the stars differ only by a factor of about a hundred, in size they differ by a factor of more than about a hundred thousand. One of the large stars is about three hundred million miles in diameter i.e., about four hundred times the diameter of the Sun and one of the smallest known stars is only about 2500 miles in diameter.

The sixth chapter deals with the nova, supernova, interstellar dust and gas which is mostly hydrogen. It describes how the centre of our local galaxy, i.e., the Milky Way, has been determined by studying the radial velocity of the stars and gas clouds within a distance of a few thousand light years from the Sun This has now been confirmed by a study of the 21 cm radiation emitted by hydrogen.

The next chapter discusses the different types of galaxies and systems of galaxies and gives an idea of the distances of the galaxies. The last chapter discusses the velocities of recession of the galaxies from us and their relation with the distances of the galaxies. A chapter devoted to the discusion of the determination of the distances of the stars and galaxies would have enhanced the value of the book. It is also to be regretted that the metric system has not been employed in the book. Even the wave length of the 21 cm hydrogen line has been given in inches

and temperatures have been given on the Fahrenheit scale.

R. N. RAI

The Ideas of Biology BONNER, JOHN TYLER. Harper Modern Science Series. Harper and Brothers, New York. 1962, pp ix-180 $ 4.95.

BIOLOGY, more than any other science is largely a collection of facts. Students find it difficult to understand these at first or it becomes clear to them later Textbooks try and present facts in a simple and orderly fashion, so that a student can learn them easily. The present book under review deals with ideas rather than facts of biology, but the ideas are based on facts as their foundations. The material given here will go along with a biology text. It is written as a supplementary reading, but at the same time it is not dependent upon a text. It can be read by the intelligent layman who wishes to discover some of the larger themes of present day biology.

The book has six chapters. The first chapter deals with the working of the cell and with the knowledge gained here, it is easier to understand origin of life and evolutionary developments. The second chapter deals with the mechanics of evolution, and the third chapter covers the study of heredity or genetics. Genetics and evolution operate together in the chain of development from the fertilized egg to the functioning adult. The fourth chapter explains the process of development and its relationship to genetics and evolution.

Beyond the individual organism there are relationships between different organisms of the same species or between groups. Thus there are colonial organisms, social organisms (like the ants and the bees), symbionts and parasites. Organisms are in constant communication with their whole environment resulting in the balance of nature where the activities of the entire community of animals and plants interlock and are interdependent. It is in this ecological setting that we catch the evolutionary mechanism in operation. In the final chapter these ideas are applied to the biology of man It deals with his development, genetics, evolution and ecology

This book can be used as a supplementary reading for the student and as an introduction for the layman to the central ideas of biology.

Viruses and The Nature of Life. STANLEY, W.M. and VALENS, E G. E P Dutton & Company, Inc., New York 1961, pp. 224.

WENDEL M. STANLEY succeeded in isolating, purifying and crystallizing a virus in 1935. Thus he raised doubts as to whether the viruses are living creatures at all. For this achievement, Dr. Stanley received the Nobel Prize in Chemistry in 1946. *Viruses and the Nature of life* presents the essential facts known about viruses and about the closely related field of genetics and cancer research. The book describes the significance of nucleic acid—a material which is probably destined to be of greater importance to mankind than the materials producing atomic energy. Besides Dr. Stanley six other authorities have contributed chapters.

The first two chapters describe the nature of a virus, whether they are dead or alive, and virus as molecules. The third chapter deals with its characteristics as a living organism The fourth chapter is on 'Virus' as a disease and its relationship to cancer The last two chapters deal with chemicals of life and the chemistry of life After describing proteins and nucleic acids, the replication of DNA and the chemistry of mutation are described. The authors have put all these facts in simple language and well illustrated by very good photographs. The book is an offshoot of a series of eight half-hour films on the subject of virus

Viruses offer us a unique key to understanding the function of nucleic acid, and perhaps, therefore, to an understanding of the nature of life itself. Viruses provide an approach to the study of evolution the process by means of which all life on earth has developed.

S. DORAISWAMI

Science for High School Students. (Vols. I &II; Ist ed.) Neuclear Research Foundation University of Sydney, New South Wales, Australia. 1964.

THE two volumes are meant for integrated four-year course in Physics, Chemistry, Biology and Zoology based on and covering the science syllabus approved by the New South Wales Secondary Schools Board of Australia. The work was attempted by the Neuclear Research Foundation Certificate integrated science text groups of authors and editors under the Chairmanship of Prof H Messel, Head of School of the Physics and Director of the Neuclear Research Foundation, University of Sydney. The panel of authors consisted of faculty members of the University of Sydney, head masters, lecturers of science subjects and teachers of science in the Sydney schools, numbering about 24. The editorial committee consisted of 8 members—Professors of Inorganic Chemistry, Theoretical Physics, Biology and Zoology and the Staff Inspector of the Education Department of New South Wales.

The total number of chapters in the two volumes is 58, followed by an appendix and a subject index The first volume has 29 chapters and the second volume has an equal number This effort followed the acceptance of the Wyndalm Report in the New South Wales which provides that every boy and girl will receive for the first four years for his/her secondary course live science instruction periods a week; a basic instruction in scientific subjects, enabling all students who go for school certificate to fit themselves better for the world they are to live in and enabling those in whom this course has engendered a thirst for further knowledge and effort, to embark better equipped on additional study and a career in a scientific or technology field.

The Wyndham scheme envisages students proceeding through the course at different speeds and at different levels. Therefore, the authors did not divide the course into four forms.

Numerous simple experiments have been given in the text in a way that even if these are not carried out, the students will be able to proceed with the text. A teachers' manual has also been prepared.

V. N. WANCHOO

Introduction to Animal Ecology. GNANAMUTHU, C. P., G.S. Press, Mount Road, Madras-2. 1963. pp. 268.

ECOLOGY which is a vast and complex subject is the meeting ground of many sciences like physics, chemistry, biochemistry, meteorology, etc. This book is a mine of information for any reader making his first approach to the peculiar problems of ecology.

The book is broadly divided into four sections Section I deals with the environment in general. In Section II, the organism is described This also forms as an account of the ecology of the individual organisms, viz., autecology. Section III is divided into two subsections dealing with the various aspects of the population of the organisms and community respectively In Section IV the ecology of the habitats of the organism like marine, freshwater and terrestrial are described. Since the study of the ecology of animals is intricately related with that of the ecology of plants, the author has made a good attempt to include the latter also in appropriate places.

By nature children are very curious about their environment and this is well reflected in the innumerable questions they ask about it But very often the incredibly dull course in biology encountered in school syllabus tries to curb their interests. The teachers should properly equip themselves by reading books like this to promote continued interest in children of the living world that lies around them everywhere. Though this book is not likely to be of any immediate use to high school children, it can make the teachers think about the problems of ecology.

There are repetitions encountered in different sections. The author himself feels this cannot be avoided in a book like this since ecology deals with a web of intricately woven relationships and the same threads are likely to be come across here and there.

The omission of photographs by the author is very much to be regretted. They are indispensable in a book on ecology. Inclusion of one more chapters on the application of basic principles of ecology to such matters as increase of food production, avoidance of pollution, atomic hazards on population, etc., would have been very much appropriate in a book like this. The price of the book is rather high and many schools may find it difficult to include this book in their indents. But the book will be very useful as a reference book to the teachers of secondary schools.

Animal Physiology. GNANAMUTHU, C. P., G. S. Press, Mount Road, Madras-2. 1962, pp. 267.

THE twentieth century has witnessed the dawn of biology as a conceptual and quantitative science with a completely changed emphasis of areas which biology has traditionally embraced. An obvious example of this is the rather dramatic decrease in emphasis on morphology and taxonomy and increase in emphasis on genetics, evolution, ecology and physiology. The study of biology will not be complete unless one gains a comprehensive knowledge of physiology which is concerned with the functional phenomenon of living things.

Animal Physiology has been published at the right moment The book is very comprehensive and the information presented is based on studies of a wide diversity of animals

There are twenty chapters dealing with water in animals and their environments, osmotic and ionic relations of animals, osmo-regulation, ionic regulation, water balance in land animals; circulation of body fluids, blood, nutrition; feeding, digestion and absorption, metabolism; respiration, energy transfer; excretion, muscle contraction, electric organs and bioluminescence, excitation and conduction receptors; central nervous function, chemical regulation by internal secretions, physiology of mechanisms of animal behaviour, general considerations.

The vast information included in the book will be used by both students and teachers. For university students this can remain mostly as an introduction to the subject. Although much of the book is not directly applicable to biology teaching at high school level, it does provide ready access to many items of information not easily found in most high school libraries or ordinary textbooks of zoology. All teachers of biology should have a ready access to this book as a source of information concerning physiological problems.

The scope of the book is larger than the title suggests, since it not only concerns itself with the evolution of functional phenomenon of animals but also with several ecological adaptations and relations explained from the functional view point. Since many of the students of biology are not likely to be quite familiar with requisite knowledge of physics and chemistry, the author has, in many instances, taken pains to explain the several physical and chemical processes to enable the readers to get a clear understanding of physiological phenomenon

Judged from the modern production standards, the diagrams are not up to the mark. Though a list of glossary of terms and index is included, a list of recent and important references is lacking

G RAJU

Rocks and How They Are Formed. Zim, Herbert S. Golden Press, New York 1961 pp 55.

THIS small book gives an interesting description of rocks, their kinds and how they are formed. Beautiful colour pictures throughout this book make it a delight, specially for the young pupils. The book explains the nature of rocks, rock-forming minerals and gives pictures of simple laboratory equipment used for the identification of minerals. The distinction between intrusive and extrusive rocks—under igneous rocks—has been illustrated beautifully.

Under sedimentary rocks, the chemical composition of lignite coal, bituminous coal and anthracite coal, have been depicted nicely Under metamorphic rocks the conversion of one type of rock into another has clearly been shown.

The last chapter explains how the rocks have been used in our lives This book can be recommended for higher secondary schools to enrich the knowledge of teachers and students in view of the changed syllabus in general science.

Instruction in Chemistry, WARRING, R.H., London Museum Press, Ltd., 1960. pp. 147.

THIS book gives instruction for about hundred interesting laboratory experiments in chemistry, which require minimum of apparatus and a limited number of easily obtainable chemicals.

The easy way of setting up a house laboratory has been explained in Chapter 1. Very interesting experiments though simple and common, such as, experiments with water, gases, acids and alkalis, metals, non-metallic substances, and semi-solids have been discussed from Chapter II to VIII Experiments given in all the chapters will enable the readers to acquire a sound practical understanding not only in the basic principles of chemistry, but also of its important applications in everyday life,—as manufacture of plastics and fibres, use of electrochemistry in plating and chemical brightening. Appendix 1, gives a list of common chemicals with their popular names and their chemical formulae. The book is useful for the students and teachers of Higher Secondary Schools

K. S. BHANDARI

Physics in the Sixties. RUNCORN S.K., Oliver & Boyd. London, 1963. pp. ii+112.

WITH the fast advances made by science in the last decade, scientific knowledge has been growing enormously and has reached a stage where it is difficult for a scientist to claim a thorough grasp over it all. There has been an ever-increasing tendency among scientific workers, especially the teachers to get hold of authentic reviews, covering the progress made in different fields.

Professor Runcorn has edited this book presenting seven reviews by some of the leading physicists, who have discussed the progress and problems in their own areas of specializations. The articles: 'Matter and Force', contributed by Professor Rosenfeld, 'Controlled Thermo-nuclear Fusion' by Sir John Cockroft, and 'the state of Physics' in which Professor R.E Peierls deals with different branches of physics, would enable the physics teachers to have a brief but penetrating review of the latest developments in the respective fields. In fact, the authors have put forth their views in such a lucid way that the articles would be comprehensible by physics teachers in general.

For some of the teachers, who are interested in the latest developments in other fields such as superconductivity, origin of the solar system, and problems of scientific research, there are different articles by distinguished scientists, who are authorities in the fields covered by the reviews.

The book will be a valuable addition to school libraries.

K. J. KHURANA

Social Insects – I. Ants

P. Kachroo

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INSECTS are grouped under the Class Insecta of the animal kingdom. More than a million different species of insects have been described and named so far. Individuals belonging to many of these species are numerous and are sometimes described as 'clouds darkening the sky' and 'swarms carpeting the ground for miles'. Some insects are large enough to be visible but a large majority are minute and can hardly be seen without the help of a magnifying glass. Notwithstanding their small size, the total bulk of animal matter in their bodies added together would exceed that of all the other land animals.

Most of the insects live on land, either on the surface, or in flight in the air above it. Many live in fresh water, mostly until they reach the adult stage, some live in water even as adults.

A few species dwell along the sea-shore above the low-water mark. Some of the land insects are migrants and make long flights over land and sea.

Insects differ in their food habits; some eat all types of plants, some every animal substance, some are selective, and yet others eat nothing at all. Mayflies and some moths and caddis flies eat nothing at all and are abstainers. Wood wasps, the majority of moths, beetles, and larvae of many insects are vegetarians. Many beetles, flies, some bugs and grass-hoppers are carnivorous, eating both living and dead animal food. Many insects, like some crickets, grasshoppers and beetles eat anything that comes in their way (omnivorous). Most of the social insects (ants, bees, wasps, termites) change from one type of diet to another in their life history: as larvae they are carnivorous and as adults vegetarians.

Some insects, like mosquitoes, are harmful to man, yet some like the honey bee and silkworm are useful.

Many insects make possible the cross-fertilization of flowering plants, by visiting the flowers in search of nectar and carrying their pollen from one bloom to another.

Some insects help nature by cleaning the earth of animal excreta, and of dead bodies. Some provide food for fish and some are used as chicken feed. Some are beautiful to look at. Some are harmful, eat our clothes, bore wood, sting, or are pests of food grains. Many thrive on human blood which they suck mercilessly. Some insects eat other insects.

A social insect is one which lives in society: each society consists of the two parents,—or at least the fecundated female,—and their offspring, and the two generations live to a varying extent in mutual co-operation in a common abode

or shelter. Thus it follows that there is a lengthening of the adult or parental life of social insects so as to allow this definitive association with the progeny.

Insect societies are based on the restriction of the reproductive function to one fertilized female, known as the queen. In ants, however, the queen may give birth to supernumerary queens. The progeny of the queen, except for those that are destined to perpetuate the species, are sterile. The sterile *forms* become the workers, and the soldiers, are endowed with special instinctive powers that enable them to do their duties. The workers are destined to work for the good of the society.

The insect society is thus the best organized social system, the queen being the mother of the colony. She lays the eggs and is the autocratic ruler of the colony. Since duties of individuals in a colony are fixed, there is never any internal trouble or revolt, nor are there any criminals. But colonies fight and rob each other just as do nations of human beings.

These insects perform their respective duties without having any previous experience, and are guided by instinct.

Insects living in well-knit societies are ants, bees, wasps and termites.

ANTS

Characters: Ants have two or more 'waists' and elbowed antennae. They have three forms: the males, the females, and the workers. The workers differ in form amongst themselves according to their functions.

The adult ants differ from all other insects in having at least one enlargement in the waist-like part of the body which produces two waists, one before and one behind the enlargement. The two waists greatly help the ants in their mobility.

The ant has unusual mouth parts. The main jaws (mandibles) and the rest of the mouth have separate functions. In most insects when the jaws are used, the mouth is necessarily open. But in ants the lower lip can be closed over the upper, completely shutting the mouth, and yet leaving the jaws free, at each side, to open or close. Thus, the ants' jaws are used both as tools, as well as 'hands' independently of the mouth.

The heads of ants have a relatively large-sized brain. The wings are absent in the workers, and are only present in the male and female. Ants have rather specialized legs, having a device combining brush and comb at the junction between the shin and foot of the fore-legs. In the abdomen there are at least three notable organs. Some ants have stings together with a gland which secretes poison to be injected by them. In others the poison is there, but the sting is replaced by a squirt with which it is discharged towards the enemy. All ants have two stomachs, the first is just the crop and the second the stomach proper. Some food in the crop passes to the stomach through a valve in between them, to be digested by the ant itself; the contents of the crop are meant to be used by the State, for the needs of the queen, the young, or the hungry.

The queen is the fully fertile female and her duty is to lay fertilized eggs for the rest of her life. These eggs are deposited in a pouch which is controlled by a valve and are fertilized one by one.

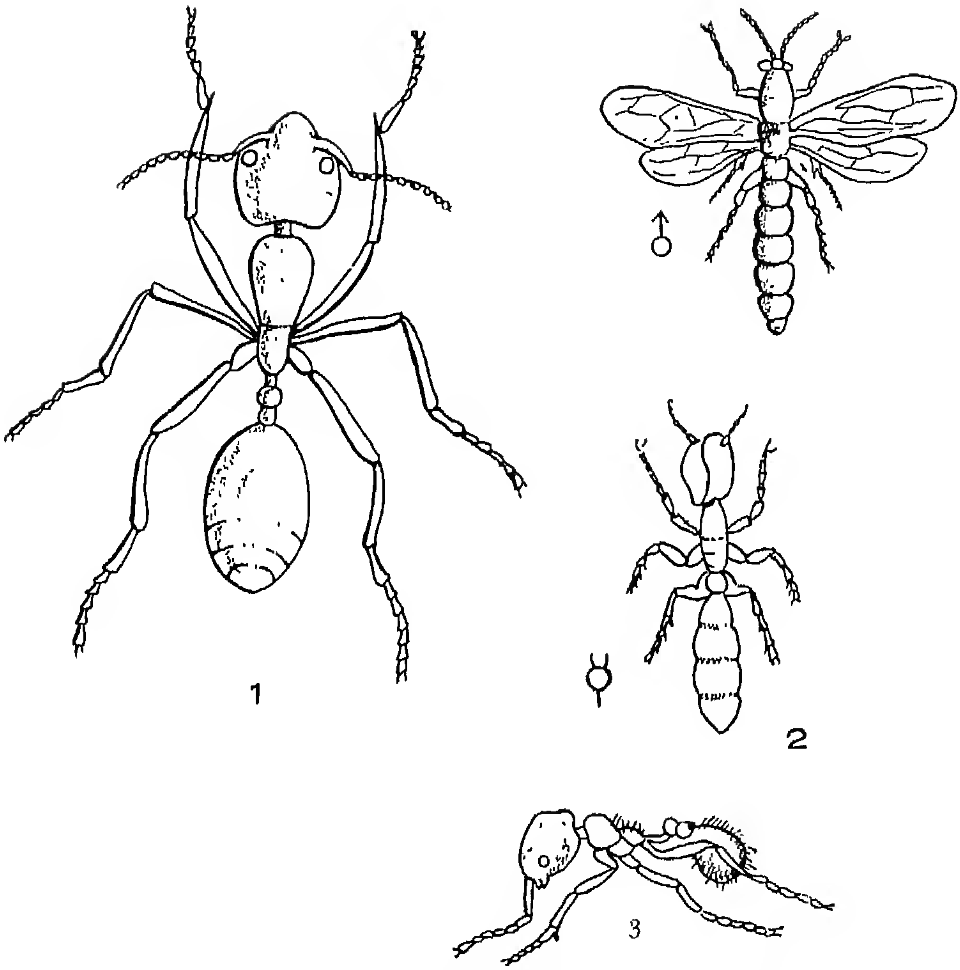

Fig. I. 1. House ant (worker); 2. Male and female ants; 3 Red ant (worker)

The males and females are of about the same size. The workers are smaller than these two and vary greatly in size. They lack wings, have much larger heads and much smaller eyes. The males have smaller heads, much larger eyes and are winged. The queens are winged first but wingless later, their eyes are larger than those of the workers, but smaller than those of the males.

Life History: Ants live together as a social community in large numbers in nests. They live as mutually dependent members of a State, or the nest. The latter may last for ever. The nest is built through common labour of some of its inhabitants.

Preparation for founding a new colony is initiated on a hot, midsummer day. The event is heralded by the flight of a winged female ant from an old nest. She is followed by other maiden queens

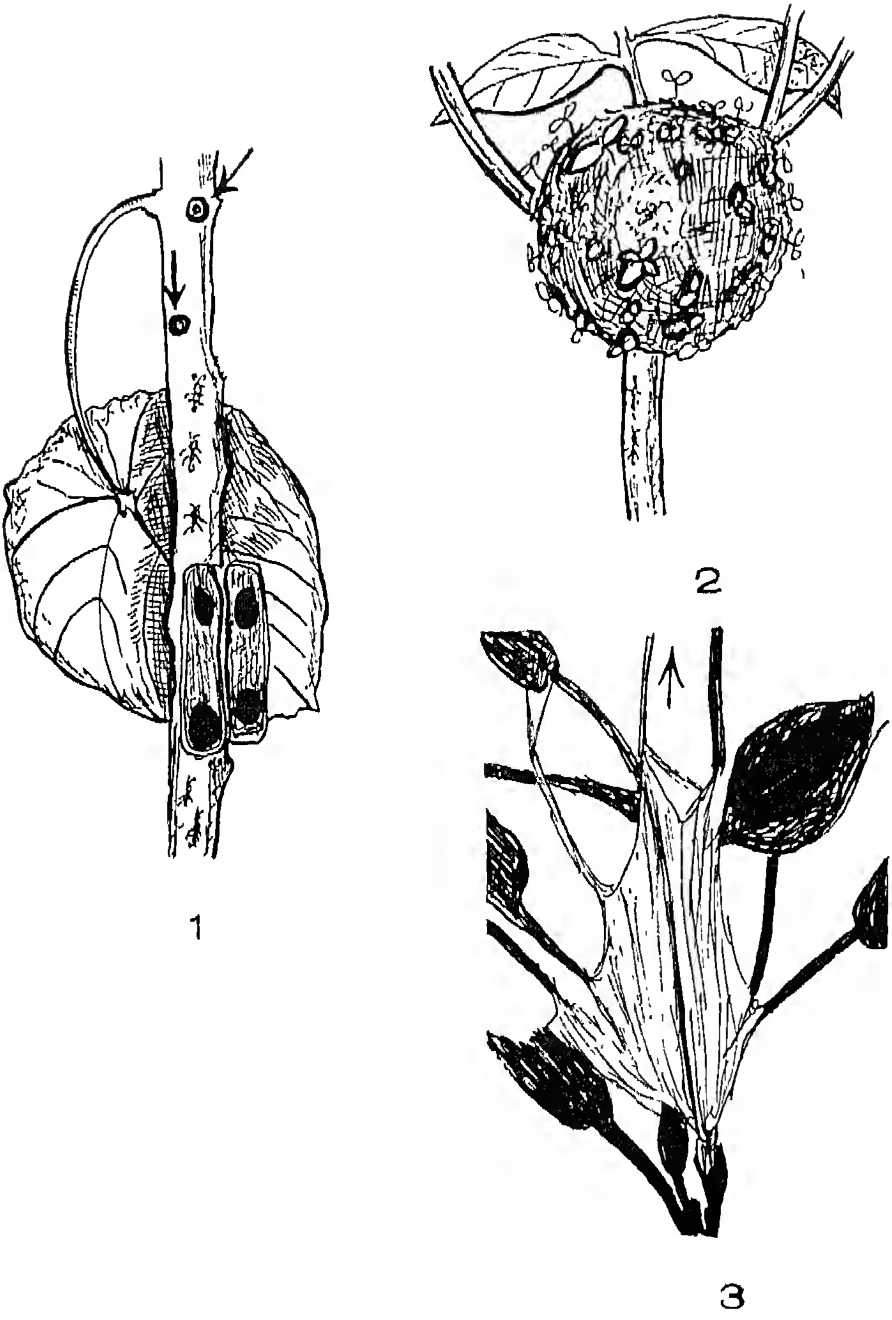

Fig. II. 1. An ant colony in a stem, the opening is at the top. 2. Ant garden in Amazon, the nest is covered with seedlings. 3. A silky nest of ants in South India.

and males from her and the neighbouring nests. Males and females pair either in the air during flight or after landing. The males die after this act. The female deposits the eggs in a pouch.

Soon the female loses her wings. She may find her way to her parent nest, or to a neighbouring nest, being welcome at both the places.

However, for founding a new colony she has to find a suitable place in the ground. She makes a hole and enlarges it into a small chamber. Here she remains in seclusion and starts fertilizing her eggs.

The eggs hatched first give rise to ants which are workers. They lay the foundations of the nest. Now the queen is fed by her worker-daughters who pump the food into her. She lays one egg every ten minutes till she lives (6 to 7 years). Some queens are reported to have lived up to 13 years. The worker-daughters manage the entire business of the nest: feeding, housing, nursing, and defending. They collect food for all, passing it from mouth to mouth, and thus ensure equality of rations. On some of them falls the duty of building and repairing the nest.

The nests of different species are variable. A nest is either dug into the soil or built with sticks, pine needles or leaves, or may be a combination of the two In either case the nest is chambered.

The workers have specific duties: some build the nest and some feed the queen and carry her eggs to special chambers built for them. There the eggs hatch into larvae. The latter are moved from one chamber to another as cold and hot, dry and wet days succeed each other, so that they may have exactly the right temperature and atmosphere. Eventually they pupate and form new individuals. For defence of the colony, a staff of porters is set at the doors, which are closed at night, or in rain or severe cold, and opened in hot weather and, normally, by day. In the winter the nest is extended deeper underground. Some species keep two different nests, one for the winter and another for the summer. Once the nest is complete with its community, it is a permanent fixture.

There may be more than one queen in a nest but there is no sign of jealousy between them. When a newly fertilized queen finds her way into a nest, she is regarded as a welcome addition to the staff of the breeding department, and nothing more.

An ant nest is supposed to go on for ever. Some remain intact for over 80 years. In the larger nests more than one queen lives and such nests may create satellite nests. But when population grows too big for a single nest, migration takes place. The surplus population moves out with one or more queens, and establishes itself in a new nest elsewhere. It is interesting to note that when the new nest is close to the old one and the ants remain in constant touch with each other, the new nest becomes a mere satellite town and citizenship is enjoyed in common between the two. But when the new nest is established far away, the communities soon become foreigners and lose the community smell by which friends are recognized. Sometimes, as in case of the fiercer species, they become enemies and are repelled and killed. The antennae are the organs through which friends and foes are known.

The ants have a long life, up to 16 years or more. During this period they

learn and teach their successors. They receive guests and sometimes provide them board and lodge as well. But sometimes their permanent guests (beetles) work differently and cause the annihilation of ants. Yet when migration occurs, the guests and other lodgers may be seen as a procession of camp-followers accompanying the ants on their march

Sometimes more than one kind of ants live in the same nest. Thus, a small species builds its tunnels and chambers in the walls separating the much wider passages of a larger species. Some species live as slaves of others. A kind of martial race is also known. They only specialize in fighting.

Some do not feed themselves or build a nest. Some are slave hunters. They steal the worker pupae of another kind and when the latter grow up, they are made to do all housework and foraging for the nest. These ants mobilize their strength twice or thrice a year and issue forth to repeat their slave raids. The queens of this type behave normally but their eggs are brought up by the slaves.

Ants live mainly on the nectar from flowers, the juices of seeds, fruits, fungi, etc The ants keep nectar aphids under their protection. Sentries are posted to defend the aphid-cattle from all invaders which belong to the nest. The paths leading to trees or shrubs on which such aphids live are also protected. Sometimes a large tree may be divided between two nests, and each will jealously defend its own side.

Our Units of Measurement—III

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IN the preceding articles of this series the three fundamental units of measurement in mechanics, namely the metre, the kilogramme and the second were dealt with. In this article, we pass on to the realms of heat and light In the case of heat, we have to discuss the fundamental units employed in thermometry and calorimetry, and in the case of light the fundamental units employed in photometry.

The Measurement of Temperature

By far the most basic concept in the study of heat and thermodynamics is that of temperature. The practical basis for the measurement of temperature is provided by the so-called zeroth law of thermodynamics which states that *two bodies (or systems) which are in thermal equilibrium with a third one are in thermal equilibrium with each other.* Since one of these bodies could be some sort of a thermometer, the temperature of any given body may be determined by establishing thermal equilibrium between it and a thermometer. For an unambiguous expression of the result of such a measurement, we need what is called a *temperature scale*

The fundamental principles of thermodynamics, which developed through the pioneering work of Carnot (1796-1832), Clausius (1822-1888) and Kelvin (1824-1907), led to a temperature scale which is entirely independent of the properties of any particular substance in Nature. This scale, defined in terms of the quantities of heat associated with a Carnot cycle, is known as the *thermodynamic scale* of temperature and is recognized as the ideal scale to which all temperature measurements should ultimately be referable. In principle, this scale could be realized rather simply by means of an ideal gas thermometer; in practice, however, neither the gas nor the thermometric procedure actually available is ideal enough for the purpose. Cumbersome corrections for these imperfections have got to be applied before the actual results can be adopted with security.

The experimental difficulties inherent in the precise measurement of temperature on the thermodynamic scale using real gas thermometers as well as the need for an easily and accurately reproducible practical temperature scale, led to the introduction of an *International Temperature Scale.* This (practical) scale was first adopted by the 7th General Conference on Weights and Measures, held in 1927, and its declared aim was to provide a scale which followed as closely as possible the thermodynamic cent'grade scale realizable at that time. The 1927 scale was revised in 1948 with a view to obtaining the closest possible agreement with the thermodynamic scale in the light of the new knowledge gained and including slight modifications (based on experience) so as to render

the scale more uniform and reproducible than its original version. The revised scale, known as the *International Temperature Scale of 1948* (*Int. 1948*) was adopted by the 9th General Conference in October 1948.

The 1948 scale was based on six fixed points (including the two 'fundamental' fixed points), to which definite numerical values (in °C) were assigned These values, in each case, defined the equilibrium temperature corresponding to a pressure of one standard atmosphere (equal to 1,013,250 dynes cm^{-2}). These fixed points were as follows:

	Temperature °C
1. Boiling point of oxygen (the oxygen point)	−182.970
2. Melting point of ice (the ice point)	0
3. Boiling point of water (the steam point)	100
4. Boiling point of sulphur (the sulphur point)	444.600
5. Freezing point of silver (the silver point)	960.8
6. Freezing point of gold (the gold point)	1063.0

The ice point and the steam point were the two fundamental fixed points, whose assigned values were meant to be exact. In the case of the remaining four points, the so-called 'primary' fixed points, the last decimal place given for each of the values only represented the degree of reproducibility of that point.

The means available for interpolating temperatures over the whole range of practical interest led to the division of the scale into four parts, using three different instruments for interpolation. These were defined as follows:

(a) the temperature region from the oxygen point to the ice point was defined by means of a standard (platinum) resistance thermometer, using a quartic formula,

(b) the region from the ice point to the freezing point of antimony (630.5°C), again by means of a standard resistance thermometer, but using a quadratic formula;

(c) the region from the freezing point of antimony to the gold point, by means of a standard (platinum, rhodium-platinum) thermocouple with the cold junction of the couple at 0°C; and

(d) the region above the gold point, by means of a radiation pyrometer, using Planck's radiation formula.

The 1948 Conference also made a number of recommendations regarding apparatus, methods and procedures to be adopted in the realization of the scale. For details, reference may be made to sources listed at the end.

It is important to mention here that besides the fundamental and primary fixed points, the 1948 scale also admitted as many as 22 'secondary' fixed points, the highest one in the list being the melting point of tungsten (3380°C). The temperatures assigned to these points were given in terms of the International Scale defined by the six afore-mentioned points and the associated interpolation formulae. These

secondary points were intended to be used as additional reference points on the scale and, hence, could serve a pretty useful purpose in practice.

An interesting, and also somewhat revolutionary, step was taken by the 1948 Conference in adopting a new adjective for the degree on the temperature scale The word 'centigrade' was discarded in favour of 'Celsius'. Thus, henceforth one had to read 56°C as 'fifty-six degrees Celsius' and not 'fifty-six degrees centigrade'.

In defence of the foregoing decision to change such a firmly established nomenclature, it may be stated that it was Anders Celsius (1701-1744), a Swedish astronomer, who was the first to divide, in 1742, the fundamental interval between the ice point and the steam point into 100 parts. And this name has already been in general use in Germany and some other countries for many years, the symbol fortunately being the same, namely °C. Moreover, unlike the rival scales named after their originators, Fahrenheit (1686-1736) and Réaumur (1683-1757), this scale was the only one which did not perpetuate the name of the man who first visualised it.

THE THERMODYNAMIC SCALE

From a fundamental point of view, it is quite clear that howsoever dependable an empirically established scale may be, we must not lose sight of our ultimate goal—the thermodynamic scale. One unique feature of this scale is the existence on it of a *naturally* fixed point, namely the absolute zero. Then, in principle, the specification of only one more point on the scale would define it completely, for the scale, as visualised, is a linear one. This position was specifically emphasized, in 1854, by Lord Kelvin, who was the first to suggest this ideal scale, defined solely through the ice point, the suggestion was repeated 20 years later by Mendeleev (1834-1907) and again in 1939 by Giauque (b. 1895).

Now, the 1948 Conference had already recognized that, with the experimental technique as is generally available, the triple point of water (namely the temperature at which its three phases co-exist) promises to be a much more precise thermometric point than the ice point. Subsequent laboratory work strengthened this view all the more, with the result that the 10th General Conference, which met in 1954, resolved to define the thermodynamic scale by means of the triple point of water as the (sole) fundamental fixed point, by assigning to it the temperature 273 16°K *exactly*. The degrees on this scale were designated to perpetuate the name of Lord Kelvin who had visualised such a scale exactly one hundred years previously.

We then have two alternative scales, namely the *International* (*Celsius*) *Scale of 1948* and the *Thermodynamic* (*Kelvin*) *Scale*. From any given temperature on the former scale, we can obtain, by adding 273 15, a temperature which is referred to as the *International Kelvin Temperature*, °K (Int. 1948); this provides an almost exact representation of the given temperature on the Thermodynamic Scale. Similarly, from any given temperature on the latter scale, we can obtain, by subtracting 273.15, a temperature which is referred to as the *Thermodynamic Celsius Temperature*, °C (therm.); this again provides an *almost* exact representation of the given temperature on the International Scale of 1948. The correspondence, how-

ever, is only approximately exact, for the reason that while one of the scales puts the ice point exactly 273.15 degree above absolute zero, the other puts the triple point of water exactly 273.16 degree above absolute zero. It is, then, natural that the size of the degree on one scale is somewhat, though only very slightly, different from that on the other. This difference, however, has got to be investigated more thoroughly before its detailed practical implications are fully realized. Meanwhile, with any declared temperature it is essential to specify as to which of the scales was originally employed.

It may be noted that with a view to bringing about further improvements in the International Scale of 1948, the 11th General Conference of 1960 has made the following modifications:

1. The scale has been renamed the *International Practical Scale of Temperature*, 1948, the introduction of the word 'Practical' is worthy of note.
2. The triple point of water has been made one of the defining fixed points of the scale, with a temperature of 0.01°C (Int. 1948), while the ice point has become a secondary fixed point, with the value 0.000°C.
3. The distinction between the fundamental fixed points and the primary fixed points has been dropped and one now refers to all of them as fixed points by definition.

The 1962 meeting of the International Committee on Weights and Measures has also made a number of tentative proposals for presentation at the 1966 General Conference. These proposals are intended primarily,

(a) to extend the range of the Practical Scale below the oxygen point, and

(b) to improve the accuracy of this scale by revising some of the values assigned to its fixed points.

Limitations of space do not permit the inclusion of an account of these proposals here; the interested reader is referred to a report which appeared in *Nature:* **197,** 1055, 1963.

THE UNIT OF HEAT

Since the very beginning of calorimetry, water has been used as a standard material for heat capacity measurements. This has been partly due to the fact that it happens to be a very convenient substance for study at ordinary temperatures and partly because it is universally available in a pretty high degree of purity. Consequently, the earliest unit of heat was defined in terms of the quantity of heat required to raise the temperature of a known mass of (liquid) water through a known range of temperature. For instance, the so-called *calorie* was defined as the quantity of heat required to raise the temperature of one gramme of pure water through one degree centigrade (henceforth to be called degree 'Celsius').

As heat measurements increased in precision, it became clear that in order to be unambiguous it was necessary to specify the mean water temperature (or the relevant interval of temperature) while defining the calorie. This specification gave rise to a number of slightly differing calories, such as the 15°C *calorie* ($cal_{15°}$) which refers to the rise in temperature from 14.5°C to 15.5°C, the *maximum density calorie* ($cal_{4°}$) which refers

to the rise from 3.5°C to 4.5°C, the *20°C calorie* ($cal_{20°}$) which refers to the rise from 19.5°C to 20.5°C, and the *mean calorie* (cal_{mean}) which was defined as the 100th part of the quantity of heat required to raise the temperature of 1 gramme of pure water from the ice point to the steam point. Caloric, one or the other, is thus the basic 'calorie' unit of heat.

As is well known, it followed from the work of Rumford (1753 - 1814) and Davy (1778 - 1829), that heat originates from motion and, in consequence, is only another form of energy. The physical equivalence between work and heat was finally and unequivocally established by the remarkably accurate experiments of Joule (1818 - 1889). Through electrical as well as mechanical experiments, Joule was able to determine the so-called Joules' equivalent of heat, which defines the quantitative relationship between the amount of work (mechanical or electrical) expended and the quantity of heat produced. In terms of the absolute unit of work, which derives directly from the metre-kilogramme-second system of mechanical units or from the relevant electrical units (see IV in the next issue), namely the *joule*, we have the following relationships (as they presently stand):

$$
\begin{aligned}
1\ cal_{15°} &= 4.1855\ \text{joule},\\
1\ cal_{4°} &= 4.2045\ \text{joule},\\
1\ cal_{20°} &= 4.1816\ \text{joule},\\
1\ cal_{mean} &= 4.1897\ \text{joule}.
\end{aligned}
$$

The 1948 General Conference, however, recommended that the quantities of heat be expressed directly in terms of the 'energy' units (rather than the 'caloric' units), and to this end adopted joule as the basic unit of heat. Of course, their resolution was appended by the remark that, 'if the experiments have been made by comparison with heating of water (and if for any reason the use of the calorie cannot be avoided), then all the information necessary for conversion into joules should be furnished.' For this purpose, it was suggested that the International Committee establish a table which will present the most precise values of the specific heat of water, at various temperatures, in 'joules per degree Celsius'. The desired table was prepared by de Haas and was accepted by the International Committee in 1950; it is available on p. 56 of the 1959 edition of the Kaye and Laby Tables.

In view of the 1948 decision, the International Conference on the Properties of Steam, held in London in 1956, redefined calorie—the so-called *I.T. calorie* (cal_{IT}) — as an exact multiple of the joule, thus rendering it independent of temperature. The resulting unit, employed mainly by steam engineers, was also recommended by the British Standards Institution in 1959; it is, by definition, equal to 4.1868 joule exactly. Furthermore, we have the *defined thermo-chemical calorie*, used mainly in the U.S.A., which was defined in 1948 to be equal to 4.184 joule exactly.

In this connection, it is worthwhile to note that these days most investigators concerned with calorimetry make measurements directly, or almost directly, in terms of the absolute electrical units. For them it is obviously simplest and best to express their results in joules rather than in calories. Habit, however, causes many to stick to their old inconveniences, so until these habits go we will continue to see the calorie used. Of course, we do look forward to the time when the use

of the joule in this field will be quite general

THE UNIT OF LUMINOUS INTENSITY

Next, we consider the international unit relevant to the domain of photometry, i.e. the evaluation of light. The quantity fundamental to this subject is the 'luminous flux', which is a measure of the resultant physical effect of the radiant flux on the eye. The luminous flux is measured in terms of the unit called lumen (lm) which is defined as the luminous flux emitted within a unit solid angle by a uniform source of luminous intensity unity*. We then have to deal with the quantity 'luminous intensity' which derives from the flux to describe the strength of a light source in regard to its ability to produce illumination.

The unit employed for expressing the luminous intensity of any given light source has, up till 1948, been the so-called *International Candle*. This was originally defined in terms of a candle of specified composition. However, in 1909, it was re-defined in terms of certain special lamps (the Carcel and pentane lamps), but was maintained by a set of carbon filament electric lamps. Unfortunately, this mode of maintenance has proved incapable of the desired degree of reliance in reproduction. With this in view, the International Committee on Weights and Measures adopted, in 1948, the black-body radiator as a standard source for this purpose. Thus, they defined a new unit of luminous intensity, named the *candela* (cd), such that one square centimetre of the surface of a black-body radiator at the temperature of solidification of platinum (2046°K) has a luminous intensity of 60 cd in the direction normal to the surface, in other words, the radiator surface has a luminance of 60 cd/cm². One finds that the new unit is approximately 0 98 of the original International Candle.

The main standardising laboratories now employ a special arrangement, shown in Fig 1, for the realization of the candela. This arrangement consists of a small cylinder of pure fused thoria about 45 mm long and of internal diameter about 2.5 mm. Its bottom is packed with

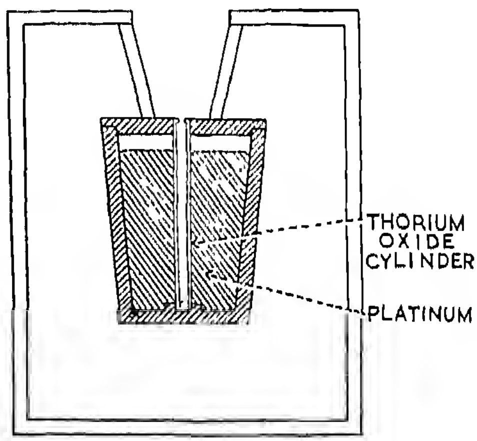

Fig 1

powdered fused thoria about 10 mm deep. It is supported in a crucible of fused thoria containing platinum. The hole in its lid acts as the black-body radiator. The crucible is surrounded by powdered fused thoria. The platinum is melted by placing the crucible in the coil of a high frequency induction furnace. The power is then reduced until the heat supplied is slightly less than that lost to the surroundings. The platinum thus

* It may be noted that for the wave-length corresponding to the maximum visual sensitivity, namely 5550 Å, one watt of monochromatic light is equivalent to 686 lumens: See Gillham, E.J. 1964, *Proc. Roy.Soc. London*, **A 278**: 137.

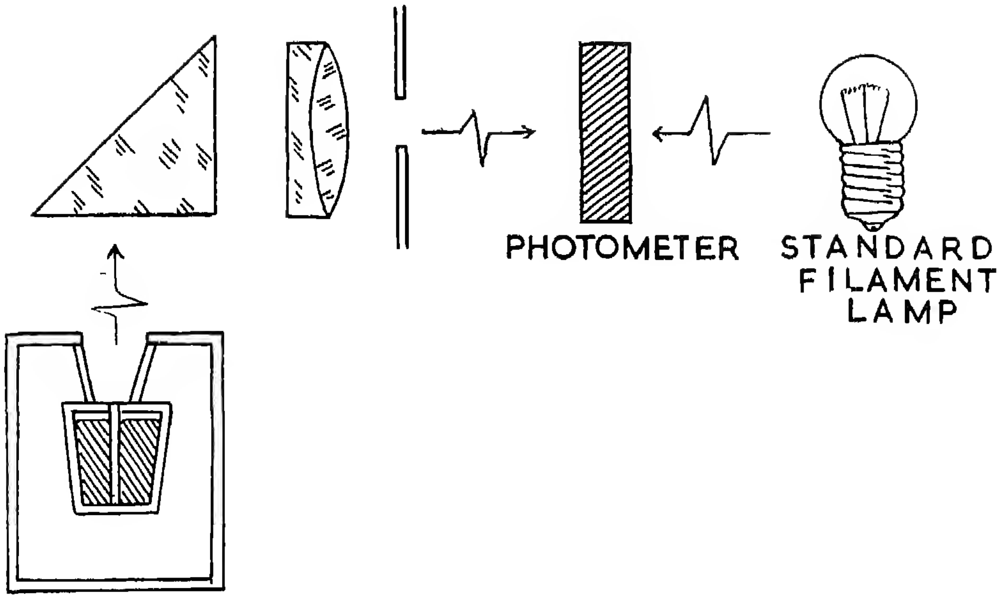

Fig. 2

cools slowly and maintains the cylinder at its melting point, whilst this is solidifying and giving out its latent heat of fusion. This condition can be maintained for about 10 minutes, the constancy of the temperature being indicated by the luminance of the radiator remaining constant.

When in use, the crucible is mounted near a photometer bench and an enlarged image of the radiator is formed on a photometer by means of a lens and prism (see Fig. 2). Viewed from the photometer, the lens diaphragm appears filled with light, and this has the same luminance as the radiator (except for transmission losses, which can be ascertained by an auxiliary experiment). Thus, the area of the hole in the radiator need not be known. Then, by the customary photometric procedure the luminous intensity of filament lamp standards is compared with that of the radiator, effecting thereby the calibration of the sources actually used in practice.

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Galileo Galilei

A NEW VISION OF THE UNIVERSE

Carlo Maccagni

Secretary, Italian National Committee for the Celebration of the 4th Centenary of Galileo

THE pages of history are filled with coincidences of persons and events which were we to notice them would strike us as extremely interesting and at times highly significant. Two such coincidences mark the dates of the birth and death of Galileo.

Galileo Galilei was born in Pisa on February 15, 1564 and died in the village of Arcetri near Florence on January 8, 1642. Now, 1564 was the year of Michelangelo's death, 1642 the year of Isaac Newton's birth. With the death of Michelangelo, the Italian Renaissance and its era of artistic splendour comes to an end. With Newton, the foundations of modern science, as we know and respect it today and which Galileo's great pioneer work did so much to create, are at last firmly established.

It is in this sense that it can truly be said of Galileo that he marks the end not only of a period in history but of a form of civilization. For, thanks to his scientific attitude and discoveries, a wide breach was opened to challenge the metaphysical and cosmological foundations of his time.

Fig. 1. *Galileo.* The discoveries of Galileo Galilei refuted the long-accepted picture of the cosmos with the earth at its centre. By his astronomical observations he confirmed the revolutionary theory of the Polish astronomer, Copernicus, of a solar system with the sun in the centre and the earth among the planets revolving around it.

The artistic and literary explosion of the Italian Renaissance had not taken place within the pedantic circles of the universities; instead it had burst forth and developed in the highly refined atmosphere of the courts and palaces of fifteenth and sixteenth century Italy. During this time the universities had remained steeped in their medieval traditions and trap-

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pings. Learning, both philosophical and theological, was purely speculative in nature and reposed entirely on the doctrines of Aristotle which had dominated Western thinking for two thousand years. The science of the university scholars was reduced to little more than abstract book-learning and, isolated and divorced from reality, had lost all contact with the exciting new techniques which were then being developed by craftsmen and artisans across the face of Italy and Europe.

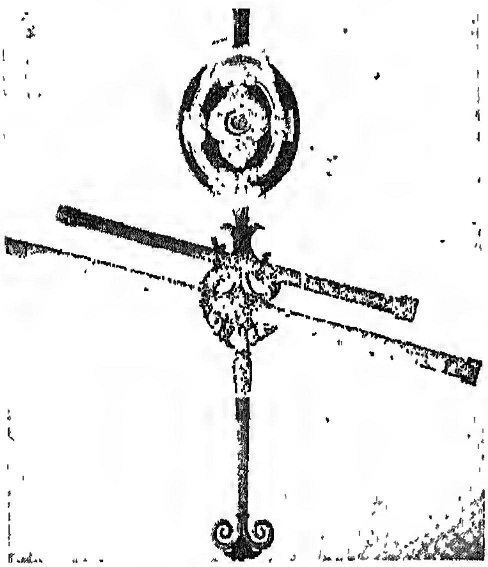

Fig. 2

The university scholars had taken over unchanged (and indeed were very proud of it) all of Aristotle's views of the physical and cosmological laws governing the world, to which had been added the system of astronomy devised by Ptolemy of Alexandria in the second century of our era. The Catholic Church had not only given its support to these views but had actually adopted them as the official Church doctrine. The natural philosophy of Aristotle as well as the astronomy of Ptolemy taught that the Earth was the centre of things and that the heavens, with the stars, the Sun, the Moon and the Planets, revolved around it in twenty-four hours.

According to Aristotle the universe was divided into two separate and totally distinct realms—the heavens and earth.

In the heavens (the domain of astronomy) everything was celestial or godly by nature and hence perfect, eternal and incorruptible, the stars and their concentric spheres all moved in perfect circles as did the Sun and the Planets. Like everything else beyond the Earth these were perfect, everlasting and immutable.

My dear Kepler, what would you say of the learned who steadfastly refused to glance through the telescope?

GALILEO has related how, in 1609, he received a report from abroad on the construction of a spyglass and applied himself to the invention of a similar instrument. 'First,' he wrote, 'I prepared a tube of lead, at the ends of which I fitted two glass lenses, both plane on one side while on the other side one was spherically convex and the other concave. Then placing my eye near the concave lens, I perceived objects three times closer and nine times larger than when seen with the naked eye. Next I constructed another one. Finally, sparing neither labour nor expense, I succeeded in constructing for myself so excellent an instrument that objects appeared nearly 1,000 times larger and over thirty times closer than when regarded with our natural vision'. Galileo eventually built hundreds of telescopes (above, two of these now in the History of Science Museum in Florence). His telescope was to bring a new vision to man, though not until intense resistance had been overcome. 'My dear Kepler', wrote Galileo to his friend, the German astronomer, 'what would you say of the learned here, who, replete with the pertinacity of the asp, have steadfastly refused to cast a glance through the telescope? Shall we laugh, or shall we cry?'

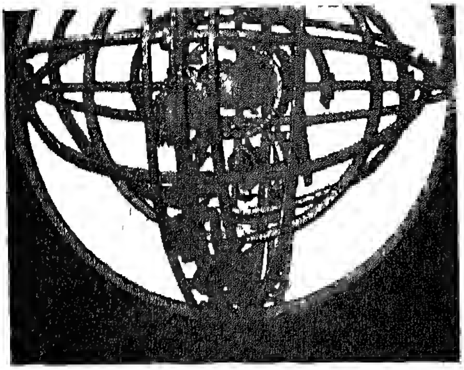

Fig 3. An early working model of the solar system arranged according to Copernican ideas—the foundation upon which modern astronomy was built.

The Earth (governed by the laws of physics) was imperfect, unstable, ever-changing and perishable. All natural and spontaneous motion could only be in a straight line. heavy bodies fell downwards toward the centre of the earth (the Earth itself being motionless in the centre of the universe), while light bodies moved upwards. All other forms of motion on earth, according to the Aristotelians, were 'violent', that is, produced by some external force acting upon a body This movement ceased immediately the force was removed. Bodies fell at different speeds while certain elements, such as fire, moved upwards. That the Sun, the stars, the Moon and indeed the whole universe rotated around the Earth appeared obvious to anyone gazing up at the

Fig. 4 Galileo presents his astronomical telescope to the Doge of Venice on August 24, 1610, offering it as a gift to the Venetian Republic. The same year, Galileo left his post at Padua University for Florence where he had been appointed as Philosopher and mathematician to Cosimo II de Medici, grand duke of Tuscany. Painting by Luigi Sabatelli (1772-1850).

heavens while the Earth seemed stable and solid beneath man's feet.

It was on this 'commonsense' basis that physics and astronomy were taught at the University of Pisa when Galileo entered it as a student in 1581, seven years after his family had moved back to Florence.

Galileo entered the 'Faculty of Artists', as it was then called, with the intention of taking a degree in medicine, but he never completed the course, and after four years left the university for good. But as a student he had already made his first important discovery in physics. Watching a lamp swinging from side to side in the Cathedral of Pisa he noticed that though the distance of each swing was reduced sharply as the movement died down the time taken for every full swing to and fro remained practically the same. Thus was born the law of the isochronism (or equal time) of the pendulum which was later applied in the invention of the pendulum clock—the first mechanism to make possible the constant and accurate measurement of very tiny intervals of time.

Fig. 5 The first Explorer of the moon

The first celestial body on which Galileo trained his telescope in 1609 was the moon. The sketches (left) made by Galileo to illustrate his discoveries cannot convey the sense of wonder and delight this new picture of the moon awoke in him. The lunar landscape that he saw through the telescope was not the smooth and spherical surface that many philosophers had believed it to be. What impressed Galileo was that it looked like a ghostly 'earthly' landscape. He described it thus 'more and more peaks shoot up as if sprouting, now here, now there, lighting up within the shadowed portion; these become larger, and finally they too are united with that same luminous surface which extends further. And on the earth, before the rising of the sun, are not the highest peaks of the mountains illuminated by the sun's rays while the plains remain in the shadows? But on the moon the variety of elevations and depressions appears to surpass in every way the roughness of the terrestial surface..' And Galileo calculated height of the mountains with an astonishing precision. Science still agrees with his estimate that they are four miles high.

'THE BEST YEARS OF MY LIFE'

The importance of this discovery, however, was far greater than this first practical application. It gave science an instrument capable of making the precise measurements required by astronomy and experimental mechanics. Galileo himself made use of the pendulum

principle to demonstrate aspects of the law of inertia.

Towards the end of his studies at Pisa, Galileo was drawing more and more towards mathematics; he concentrated in particular on the works of the great Greek scholar Archimedes and developed a special interest in geometry and mechanics.

By 1589 he was so well versed in these subjects that the University of Pisa appointed him as its Professor of Mathematics, a post he held for three years. During this period he carried out his experiments on falling bodies and, as legend has it, dropped objects of different weight from the top of the Leaning Tower of Pisa to prove that they would fall with equal velocity and with uniform acceleration.

After writing treatises and dialogues 'On Motion' (in Latin, according to the tradition, under the title *De Motu*) Galileo then embarked on more original research in the field of mechanics and constructed his *Bilancetta*, a hydrostatic balance for weighing substances in water.

Galileo's fame as a scientist was now spreading in academic circles. He passed on the results of his research to other scholars, and established close personal contacts with some of the most distinguished philosophers and mathematicians of his time.

Gelileo's reputation and scientific training as well as the help of influential friends now procured for him the post of Professor of Mathematics at the University of Padua—an appointment made by the Senate of the Venetian Republic.

Padua provided the ideal element for Galileo. He remained there from 1592 to 1610 and in a letter to a friend written many years later when he was old and blind, he recalled this period as 'the best 18 years of my life.'

DUST TURNED TO STARS

Padua, a neighbouring city to Venice, had preserved to the full its ancient and vigorous university tradition. It was the cultural capital of the Venetian Republic, whose Senate took an immense pride in the university and allowed its Faculty and students the greatest freedom of thought and opinion. The nobility of Venice was also passionately drawn to the arts and sciences, and its members were proud to have friends among the professors of Padua.

In the lively atmosphere of this university, with its exuberant outlook and its opportunities for free, critical, open-

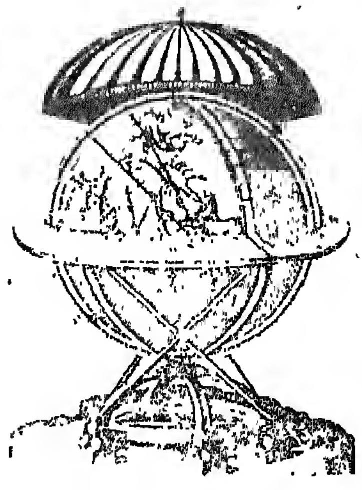

Fig. 6. The Globus Magnus of Tycho Brahe. In the cosmic system invented by this Danish astronomer just before Galileo began his observations of the heavens, the planets Mercury, Venus, Mars, Jupiter and Saturn moved in orbits, around the sun while the sun moved in an annual orbit round the earth.

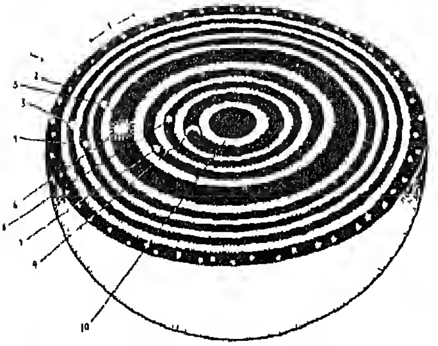

Fig 7. The spherical cosmos of the Greek astronomer, Eudoxus (1) propelling sphere-invisible, immovable, (2) star sphere (carries other spheres with it) period of revolution: 1 day; (3) Saturn sphere 29 years; (4) Jupiter sphere 12 years; (5) Mars sphere 2 years, (6) Sun sphere—1 year, (7) Venus sphere 6 years; (8) Mercury sphere —3 months (9) Moon sphere 1 month; (10) Earth sphere immovable. From ' *Pictorial History of Philosophy* Philosophical Library Inc. New York.

OLD VISIONS OF THE UNIVERSE

In their efforts to reform astronomy both Copernicus and Galileo turned to writers of the Ancient World to see what theories they had to offer, and in particular to those of Pythagorean astronomy. In the 5th cent B.C this school had pictured the universe as a system with circular orbits whose pivot was a 'central fire', around which swung the earth-itself an errant body like the rest. Ptolemy, in the 2nd century A D. conceived a complex cosmic system in which, the earth stood immobile in the centre of the universe, with the stars and the planets moving around it. Ptolemy's theories held sway for 15 centuries. About 1520, Copernicus returned to the Pythagorean theory which places the sun in the centre of the system. Men scoffed at the theory of Copernicus until the work of Galileo confirmed his reasoning. Illustrations on this page illustrate some ancient views of the universe.

minded discussion, Galileo was quick to form new contacts and friendships. He became a well-known figure in Paduan and Venetian circles. Here he formed a close and lasting friendship with a nobleman, Gianfrancesco Sagredo, who later

Fig. 8 How the ancient Hindus saw the world. An early conception of the universe, in which the world was supported on the backs of four elephants, standing on a gaint turtle (See in the Centre of the Map Unesco Courier, March 1956.)

Fig. 9. From left, Urania, muse of Astronomy and Ptolemy in this illustration from a work by Jean de Holliwood, published in Paris in 1521. Above them is the Ptolemaic conception of the cosmos with the earth at the centre.

became one of the interlocutors of the famous Galilean *Dialogues*. Watching the dockyard workers of Venice at their tasks Galileo found new and rewarding material for scientific reflection.

Like most of the university professors of his day, Galileo had a number of students lodging at his home to whom he gave private tuition. He also set up a small workshop under the direction of a mechanic named Marcantonio Mazzolani, where geometrical, astronomical and navigational instruments were made. One of these was the famous 'geometrical and military compass' conceived by Galileo in the first years of the seventeenth century. It was a kind of slide rule with which certain operations in arithmetic and geometry could be done mechanically, it was also used to solve problems relating to fortified works.

It was also from this workshop that the famous telescope that Galileo constructed with his own hands in 1609 is believed to have come. By introducing the telescope as a scientific instrument Galileo revolutionized astronomy and cosmology and laid the foundations of modern science.

As Galileo himself relates, he set out to make the telescope fired by his inborn desire for knowledge and his urge to verify the findings of others—in this case because he had heard that a spectacle maker in the Low Countries had devised an optical instrument 'by means of which visible objects though very distant.. . were distinctly seen as if nearby.'

After many attempts he managed to produce a telescope which though not very powerful was of sound design, and then others, one of which he presented to the Venetian Senate. Then, realizing the vast possibilities of the instrument for astronomical research, he began to use it himself for scanning the heavens.

The results were at once so encouraging that he was spurred on to continue his research and extend his investigations. So great was his enthusiasm that all his discoveries in the realm of astronomy came in one tremendous explosion of new-found cosmic knowledge, within the space of a single year.

It is now-a-days difficult for us to imagine how Galileo felt when, looking through his telescope for the first time, he beheld the heavens spangled with stars that no man had ever seen before. What he witnessed was the repudiation of all the traditional theories, in fact of everything that philosophers and astronomers had ever taught the immutability of the heavens.

But was it not perhaps the fault of the instrument? Was it deceiving his eyes? What was he to believe—the wisdom handed down over the centuries or the evidence of his own eyes? He had, after all, tested his telescope on nearby objects also visible to the naked eye and these had not been altered in appearance, but merely magnified.

Perhaps indeed this was a sign that a new era was at hand and that Copernicus had been right to attack the Ptolemaic system after all? And if this new instrument could be used to explore the uncharted expanses of the heavens it would perhaps prove beyond doubt the validity of the Copernican theory of astronomy, whose simplicity had already convinced Galileo of its worth.

Such doubts as these must have assailed Galileo as he continued his research;

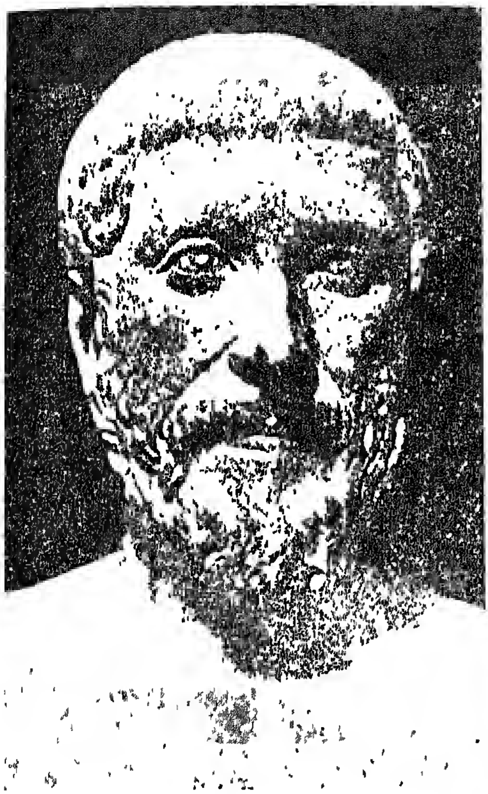

Fig 10 Pythogoras

Fig. 11. Copernicus

each night brought new elements to add to the already formidable body of irrefutable evidence against Ptolemaic astronomy and Aristotelian cosmology

BOWED BUT UNCONQUERED

One of the first discoveries which Galileo made, after being struck by the amazing number of fixed stars, was that both the Milky Way and the great Nebulae were themselves composed of multitudes of stars and not of particles of dust, vapour or clouds as traditional astronomy had always maintained.

The first celestial body he studied was the Moon, according to tradition a smooth, uniform and precisely spherical body composed of absolutely pure matter Galileo saw at once that it was 'uneven, rough and full of cavities and prominences'—in other words, traversed by valleys and mountains. He noted too that it was unevenly illuminated

Thus the Moon, by its shape and its surface, appeared to closely resemble the Earth This disturbing resemblance refuted the ancient dogma of Aristotle about the heavens being both perfect and incorruptible: it also challenged the worth of the entire traditional cosmological system, and threatened in consequence the accepted metaphysical one and the theological system founded upon this.

On the night of January 7, 1610, while Galileo was observing the planet Venus, he noticed three more celestial bodies which, unlike the fixed stars, appeared to

Fig 12. *The Book that Shook a World* More than 2000 years ago Pythagoras, the Greek and his followers accepted the idea that earth rotates on its axis and travels around the sun which is placed at the centre of the universe. But the ideas of Aristotle, the Greek Philosopher (4th century B.C.) on the earth's immobility at the centre of the universe continued to dominate the Western world Ptolemy's astronomy of the 2nd century A.D. was also based on this idea. In 1543, Nicolaus Copernicus, a Polish astronomer published his 'De Revolutionibus' which claimed the earth revolved around the sun. In 1632, Galileo wrote his Copernican manifesto, the Dialogue on the Great World Systems. The frontispiece of the original edition (above) shows Copernicus debating the systems with Aristotle, whose followers continued to oppose the new Copernican view of the universe.

move around the planet as if this was the centre of their system Continuing his observations on succeeding nights and noting the regular periodicity of these stars, Galileo deduced that they were indeed satellites, and by January 14 he had discovered yet a fourth satellite of Jupiter.

Thus he reasoned, there exists in the Universe another centre of rotation other than the earth. Because of the actual movement of the Moon and the apparent movement of the Sun, the fixed stars and the entire celestial sphere, the Earth had hitherto been regarded as the unique axis of the cosmos. Now, more and more proofs were found to support the Copernican ideas of cosmology.

Galileo decided to reveal his discoveries to other scientists. He did so in March 1610 in a sixty-page pamphlet entitled *Siderius Nuncius* (The Starry Messenger) which was published in Venice. The reactions it provoked ranged from enthusiasm to suspicion, curiosity and distrust. Above all it gave rise to endless discussion.

To clarify his position Galileo left Florence, where he had gone to live after leaving the University of Padua and being appointed philosopher and mathematician to the Court of the Medicis, and set out for Rome. Here, in the spring of the year 1611 he was given a triumphal reception. The fathers of the *Collegio Romano*, the supreme authority in cultural affairs at that time, recognized his discoveries. The select Accademia die Lincei (the lynx-eyed), presided by Prince Federico Cesni, elected him a member (the sixth), an honour he prized so highly that there-

after he always signed himself 'Galileo Linceo'.

While in Rome and on his return to Florence he pressed on with his research, calculated the time taken by the 'Medicean Stars' to rotate around Jupiter and journeyed ever further into the new world revealed to him by his telescope.

The telescopes he made and others copied from them were by now to be found in all parts of Europe. Scientists and laymen fired with curiosity scanned the skies with the aid of these new instruments and in no time at all more had been added to the knowledge of astronomy than in all the thousands of years gone by.

On July 25, 1611, Galileo observed that Saturn was 'tripleformed'. His telescope was not powerful enough to show him the rings around this planet. He saw it as an oblong-shaped rather than a spherical body, and even as having three parts—a larger central body flanked by two smaller ones. It was not until 1655 that Huygens, the Dutch mathematician and physicist, using a much more powerful instrument, perceived the ring around Saturn.

In the meantime, Galileo had also observed the spots on the sun. This was a revelation of major importance for the supporters of the Copernican system for it demonstrated that the sun itself—this 'noble' and 'perfect' body—was also subject to changes not acceptable to Aristotelian theory. Galileo was able to show that from observations of these spots one could prove the rotation of the sun, and even compute the speed with which it rotates upon its axis.

Already as early as December 1610, Galileo had observed the phases of Venus which was another striking proof that the centre of the orbit of that planet was not the Earth but the Sun.

In the books and letters by which he announced his discoveries to the world of learning, Galileo consistently affirmed his belief in the theories of Copernicus, which had now been confirmed by so many convincing proofs. But it was above all in one single work that he described all the results of his years of research in astronomy and mechanics. This was the *Dialogo sopra i due massimi Sistemi del Mondo* (Dialogue on the Great World Systems) whose publication in 1632 was the signal for an onslaught on Galileo by all the forces of reaction, all those who refused either to understand or to concede the facts that had been proved by experiment and reasoning.

Galileo had already received a sharp warning in 1616 and had been told not to uphold or teach the Copernican doctrine which the Church had condemned as erroneous; and he had, officially at least, bowed to this injunction. When Maffeo Barberini, who had often shown marked favour to Galileo, was elected Pope with the title of Urban VIII, the scientist believed that he could now freely and openly express his scientific views. Thus, after visiting Rome in 1624 to pay homage to the new Pope, Galileo set about completing his *Dialogue*, which in reality, he had been pondering on since his days in Padua.

For publishing this work Galileo was summoned before the Tribunal of the Inquisition. He was charged with violating the injunction of 1616 in that his new

book, while paying lip service to official views, was in fact defending the Copernican doctrines

The trial lasted from February 1633 into the summer of that year. Galileo was condemned to imprisonment and ordered to recant. Subsequently the prison sentence was commuted to confinement in the residence of the Grand Duke of Tuscany in Rome, and he was later authorized to move first to Siena, and finally to Florence.

Despite the condemnation, which was to have far-reaching repercussions on scientific life in Italy, Galileo did not capitulate. He worked on until he had completed his greatest and most mature work, *Discourses and Demonstrations on Two New Sciences*, which was published at Leyden in 1638.

The *Dialogue on the Great World Systems* and the *Discourses* are Galileo's major works and together form the basis of modern dynamics

In the *Dialogue*, Galileo embarked on his great defence of the Copernican doctrine; in the *Discourses* he developed the theme of his earlier work in far greater depth and detail, confirming his conclusions by practical demonstrations. In this work Galileo set out the results of half a century of scientific research systematically expanding and summarizing his discoveries and conclusions.

The measure of Galileo's greatness was that he saw through the superficial and deceptive appearance of quite ordinary, everyday things and grasped the reality behind them that other men had never been able to perceive. The key to Galileo's achievement was the completely new method of scientific research that he himself had devised.

Galileo made use of a powerful battery of arguments in his assault on the theories of traditional science. He advanced the universal principle of relativity, formulated the law governing the free fall of bodies, defined the principle of inertia and studied the composition of motions And, perhaps most important of all he considered the problem of the 'truth' and the 'validity' of the science of the universe from a viewpoint that still is 'modern'.

Galileo used a revolutionary approach. His weapon was the principle of relativity and with it he swept aside all arguments advanced against the idea that the earth rotates. From the most commonplace experiments and observations came principles that none of Galileo's predecessors had been able to grasp or expound.

The Galilean principle of relativity maintains that it is impossible to tell, from mechanical experiments carried out within a given system, whether that system is in a state of rest or in uniform linear motion. In this way Galileo refuted arguments against the earth's rotation based on facts observed on the earth itself, that is, from within the same system.

To support his hypothesis Galileo used the example of a ship. He pointed out that it is impossible for anyone inside a vessel to tell whether it is in motion simply by observing animals or objects in movement within, since there are no observable relative changes between

these animals or objects due to any movement by the ship. Moreover, he affirmed, there is no absolute motion, either celestial or terrestial, rotatory or linear, upwards or downwards; there is only motion in relation to a point that is assumed to be fixed.

To determine whether celestial bodies are stationary or in motion, astronomers still take as their point of reference three axes traced within the solar system (and called the Galilean axes in honour of the great scientist) by which motion can to some extent be measured, though subject always to relativity.

Fig. 13. Galileo became blind a few years before his death in 1642, but continued to work energetically. He maintained his scientific correspondence and, as shown in this painting by Luigi Sabatelli, dictated his ideas to his disciples, Vincent Viviani, the mathematician, and Evangelista Torricelli, the physicist.

Some of the commonest arguments to support the view that the earth is motionless had been based on observation of moving bodies, and more particularly of projectiles, on its surface And these movements of course showed none of the effects which it was wrongly believed should be produced by the earth's rotation

But although the principle of relativity had now provided a satisfactory explanation on this point, there still remained the problem of the 'spontaneous' movement of bodies and the 'violent' motion of projectiles

By experiments, Galileo demonstrated the error of Aristotle's theory that the velocity of a freely-falling body is directly proportional to its weight, and showed that all bodies in free fall towards the earth have the same velocity. These experiments led Galileo to his studies on inclined planes.

Objects dropped from towers or buildings could only be observed in movement for a matter of seconds and thus little information of value was obtained from such experiments. With the inclined plane, however, it was possible to prolong the time of fall and to control and measure the velocities produced.

By experiments of this kind and others carried out with a pendulum, Galileo demonstrated that all velocities reached in descending from the same height, but along planes of different inclination, are nevertheless always equal. He was thus able to formulate a new basic principle of dynamics; the principle of inertia. This states that the velocity of a weight moving along an inclined plane accelerates in proportion to the

angle of slope of the plane, and accumulates enough energy (allowance being made for the effects of friction and air resistance) to return, like the pendulum, to the same height from which it started.

The formulation of the principle of inertia becomes complete when it is shown that, unless outside forces intervene, a body remains at rest (which even the Aristotelian school admitted) or in uniform motion. This was a postulate which ran counter to all the ancient theories on the contrast between natural and 'violent' motions, and it affirmed that these motions, which had hitherto been regarded as entirely different in nature, could actually be combined.

Applying the principle of inertia, the law of free-falling bodies and the principle of the composition of motions, Galileo was able to split up projectile motion into its component parts; the motion of inertia operating in the direction and at the velocity of the initial impulse, and a downward motion due to gravity. The result is a parabola. Galileo was now able to draw up the first firing tables, which are reproduced in his *Discourses*.

This, in my view, was one of the greatest moments of Galileo's scientific career. He was now possessed of the facts that were required in order that the work begun by him might be completed by the English scientist, Sir Isaac Newton, nearly half a century later. Newton was able to complete his elaboration of the scheme of the Universe by applying to the motion of heavenly bodies Galileo's analysis of the dual forces (inertia and gravity) which govern the trajectory of projectiles. Thus were laid the foundations of modern scientific development.

Galileo had faced the humiliation of his condemnation with firm courage, convinced beyond all doubt that his was the path of truth. This was his 'Credo' and he never ceased to proclaim it to the world.

In questions of science the authority of a thousand is not worth the humble reasoning of a single individual.

Galileo Galilei

Some Remarks on Teaching Different Bases

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THERE are several well-known reasons for teaching notation systems in different bases. Perhaps one of the most important reasons for teaching different bases is to help pupils acquire a better understanding of fundamental properties of base ten. However, the usual approach to teaching different bases as I have seen it presented in recently published textbooks and current mathematical literature does not give pupils a clear understanding of what they are doing. Thus, pupils see little or no relationship between notation systems in different bases without understanding the reasons for what they do. It is a well established fact that teaching students to perform operations based on memory (without understanding) serves no useful purpose. In fact, Dr. Fawcett says:

> No student will be guided toward an understanding of mathematical method through teaching procedures which feast his memory and starve his reason.
>
> (Dr. Harold P. Fawcett, 'Guidelines in Mathematical Education.' *The Mathematics Teacher*, LIII, October 1960.)

Thus, it will be the purpose of this article to present an effective method of teaching different bases.

To begin the presentation, suppose that we consider the following set of tally marks. (arbitrarily selected)

At this point it is explained to the pupils that different bases simply mean that we count in different groups such that each group contains the same number of objects. Thus, using base ten first with which pupils are already familiar (but do not understand how it works), the tally marks (hereafter called marks) are counted by groups of tens. In Figure 1 there is one group of ten marks and seven marks left over. The pupils can very

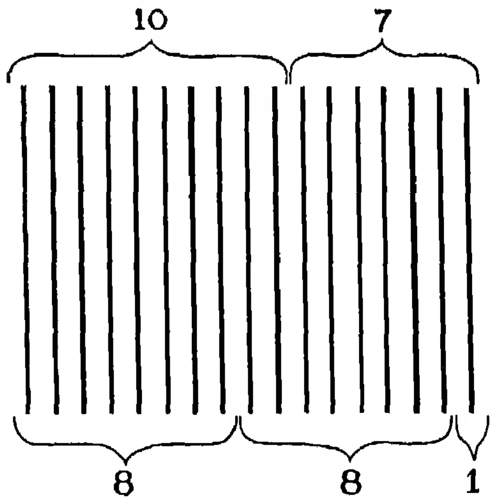

Fig. 1.

easily verify the fact that there are seventeen marks by counting them. This

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means that the results can be written in a more concise manner as 17. Pupils can do this in base ten because they have already learnt something about place value but do not understand how or why it works. (That is one of the main reasons for teaching different bases). Pupils have learned something about positional notation as *follows*:

ten thousands	thousands	hundreds	tens	ones
10^4	10^3	10^2	10	10^0

Thus, referring to Figure 1 again the, pupils immediately recognise that we have one ten and seven ones, giving 17. Next we refer to Figure 1 and count in groups of eights. The question arises now as to how may we write the results in a concise manner? Well by using the analogous notation for base ten we may write a similar notation for base eight as follows·

sixty-four	eights	ones
8^2	8	8^0

Therefore, looking at Figure 1 we have two groups of eight objects and one left over. In a concise notation we write 21_{eight} (meaning two groups of eight objects and one left over). Obviously it follows that we have the same number of marks but the notation is different. From Figure 1 the student can immediately conclude that $21\ eight = 17_{ten}$.

After doing several examples as illustrated in Figure 1 we go a step further. Suppose a number in base ten is given and we wish to change it to base eight (without using marks). Actually what we wish to do here is to find out how many groups of eights are contained in the number given in base ten. This problem is approached by first doing ordinary division or reducing common fractions, which I shall not illustrate here.

Consider the following problem· change 26_{ten} to base eight. This problem is done as follows: First the pupils write down the positional notation for base eight as follows· eight^3 eight^2 eight eight^0. Secondly, the pupils ask themselves these questions: Does 26 contain eight^0? Yes. Does 26 contain eight? Yes. Does 26 contain eight^2? No. Therefore eight is the largest divisor. After pupils have answered these questions they proceed to solve the problem as illustrated in example 1.

Eight^1 = 8	26	3
Eight^0 = 1	2 2	2
	0	

Example 1

Thus we started with the largest possible divisor (eight) and continued 'on down the line' to eight^0. Therefore $26_{ten} = 32_{eight}$. The results can be checked by simply converting 32_{eight} to base ten as follows:

$$\begin{aligned} 32 \text{ means } 3\ (\text{eight}) + 2\ (\text{eight}^0) &= 32 \text{ eight} \\ &= 3(8)+2(8^0) \\ &= 24+2 \\ &= 26_{ten} \end{aligned}$$

For a second example consider the problem 786 containing three digits to be changed to base eight. First the pupils write...eight^3 eight^2 eight eight^0. Second, the pupils determine the largest possible divisor (by asking same questions asked in example 1). Then the pupils proceed

to solve the problem as illustrated in example 2.

$\text{Eight}^3 = 512$	786	1
	512	
$\text{Eight}^2 = 64$	274	4
	256	
$\text{Eight}^1 = 8$	18	2
	16	
$\text{Eight}^0 = 1$	2	2
	2	
	0	

Example 2

Thus $786_{ten} = 1422_{eight}$

The method which has been illustrated in examples 1 and 2 eliminates the process of 'repeated division' and 'keeping the remainders' as I have seen it done in a very large sampling of recently published textbooks and current literature on the teaching of mathematics. The fault that I have found in the 'repeated division' process is that pupils on the junior high school level as well as other levels find it rather difficult to *Understand* precisely what they are doing.

Beyond this point of understanding, we begin to use the polynomial form for changing any base to another base. However, this method requires that pupils know how to add and multiply in the base under discussion (which has already been taught before we reach the point). The polynomial method eliminates the division process as illustrated in examples 1 and 2. For example, consider the problem in example 2. (change 786_{ten} to base eight)

a $786_{ten} = 7(10^2)+8(10)+6(10^0)$

$= [7(12^2)+10(12)+6(12^0)]_{eight}$ (convert notation in base ten to notation in base eight)

$= [7(144)+10(12)+6(1)]_{eight}$ (perform operations in base eight)

$= [1274+120+6]_{eight}$

$= 1422_{eight}$

b. Change 1422_{eight} to base ten

$1422_{eight} = 1(\text{eight}^3)+4(\text{eight}^2)+2(\text{eight})+2(\text{eight}^0)$

$= 1(512)+4(64)+2(8)+2(1)$

$= 512+256+16+2$

$= 786_{ten}$

Finally, pupils are able to discover that in a place value system of numeration a numerical like 6,305, is simply an abbreviation for a polynomial in base b, like $6b^3+3b^2+0b+5b^0$. Once pupils have discovered this fact, then they can change any number in any base directly to the corresponding number in another base. That is, for example, they can change a number in base five to base twelve without any difficulty. The only small matter involved in going to base beyond base ten is that we simply must 'invent' new symbols.

Thus, once pupils reach this point of understanding they can perform all of the operations we do in base ten, and above all have a better understanding of how base ten works and what makes base ten work as it does. Furthermore, pupils discover that any number N, base b, may be written symbolically as follows :

$$N_b = \sum_{i=0}^{n} b^i k_i$$

which implies that

$$N_b = \sum_{i=0}^{n} b^i k_i = b^n k_n + b^{n-1} k_{n-1} + b^{n-2} k_{n-2} + \ldots + bk + ko$$

International Years of the Quiet Sun

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OUR sun is a star, the nearest star from the earth, only 93 millions miles away. Man has always been interested in the sun which gives us light and heat. The tiny earth at this great distance is able to capture only about 2 billionth part of the total solar radiation in space in all directions. Yet it is realized by very few that most of the sources of energy on earth are ultimately derived from this solar energy. The driving power of the wind or the running water is directly traceable to the sun. Sunlight is locked in green plants by photosynthesis, and from the plant life of the carbonaceous age, millions of years ago, have originated our coal and petroleum deposits. Only nuclear energy, which still has a very limited use, is independent of sun.

Scientists have all along been keenly interested in the nature of the sun and its relationship to the earth. Much information about the sun is now known. It is believed that the surface temperature of the sun is near 6000°C, while the interior may be very much hotter. A turbulent gaseous layer about 6000 miles thick is called the 'chromosphere' where the temperature ranges probably from 30,000°C —60,000°C. Still outside is the thin gaseous envelope called the 'corona', extending over millions of miles where the temperatures are estimated to be even much higher. There is constant change in the outer zones of the chromosphere and the corona.

Physicists have been attracted to the rapid changes and activities taking place on the sun's surface. A convenient measure of solar activity are the sun spots. These appear as gigantic whirlpools of gas, rapidly moving in a spiral motion like the cyclonic storms of the earth's atmosphere. The gas mass spirals outward from the sun's interior. Moving outwards to regions of lower pressure it gets expanded and cooled. These sun spots increase and decrease in number in a fairly regular way. In a cycle of ten to eleven years, there appears a gradual increase, a definite peak of solar activity which subsequently declines and reaches a minimum, at the end of the cycle. There may, however, be an overlap between an old and new sun-spot cycle.

The solar radiation apparently consists of visible light and heat. Scientists have found that the complete solar radiation extends over a wide spectrum including infra-red, ultra-violet, X-rays, gamma radiations and radio waves, besides visible light and heat rays.

The ultraviolet and X-radiation from the sun are absorbed by the upper part of the earth's atmosphere causing the for-

mation of an intensely electrified zone at a height of 40 to 300 miles above sea level. This layer is called the *ionosphere.* It acts as a reflector of radio waves of a certain range of frequencies. When the sun is near or at maximum activity, great solar storms cause electrical disturbances in the ionosphere and upset radio communications on the earth

The study of radio waves of the sun has opened the new field of solar radio-astronomy, through which invaluable clues of the solar atmosphere and its disturbance are obtained.

The International Geophysical Year or IGY (1957-58) was an international cooperative scientific research programme. The one-year period was the time of maximum activity of the sun During this period scientists from many countries studied the earth, its structure, its atmosphere, surface water and ice, its relationship to the sun and space, etc. The discoveries made and information and data collected, were pooled and exchanged. The cooperative venture was a great success. The studies, however, brought forth many more new questions and problems.

Encouraged by the success of the IGY and the new geophysical problems, scientists of 62 countries decided to plan a similar programme of international co-operative scientific research to study the influence of the sun on the earth when the sun is quietest. This programme is known as the IQSY or the International Years of the Quiet Sun. It has already commenced on January 1, 1964, and will continue till December 31, 1965

During this period of quiet years, scientists will explore the atmosphere with all known techniques. They will study the nature and causes of the mechanisms involved in changes of weather. The studies will include ground measurements of various data, temperature and wind movement at higher altitudes with instrumented balloons, estimation of concentrations of trace elements in air, the gain and loss of infra-red and heat energy in the atmosphere, causes of sudden warming of stratosphere making changes in wind patterns, etc Rockets and satellites will carry self-recording instruments up to the highest reaches of and even beyond the atmosphere

During this period, though sun-spot activity will be at the minimum, they will still be occurring in isolation. This will enable the scientists to make a detailed study of the formation of sun spots. It may help in further understanding of the earth and sun relationship.

At this time the highly tenuous gases in inter-planetary space will be least disturbed. The ionosphere of the earth is also least opaque to the radio waves from the sun and the cosmos. Hence the cosmic rays reaching the earth will be least shielded. The IQSY will thus help the study of the cosmic rays and give clearer understandings of the origin of stars, galaxies and the universe.

Why Are Cells So Small?

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WHY are cells so small? This is a question frequently asked by students when they are introduced to the concept of the cell. The teacher may glibly answer this question for the student but it has been my experience that the usual presentations on surface area-volume relationships leave many students confused and unsatisfied. In science today we often use the 'discovery' approach in order to secure maximum student involvement and retention. In the following paragraphs is described such an approach to teaching this fundamental principle.

The first step in the sequence is for the teacher to anticipate the time when this question of 'Why are cells so small?' will arise in his classroom by preparing mimeograph work sheets set up in such a way that the area of a cube may be calculated four times, using increasing values each time, down the left side of the page. Set up the right side of the page for four calculations, using same values in same sequence, for the volume of a cube. Do the same for the calculations to be made on both the area and volume of a cylinder and a sphere. These calculations could be assigned as homework for the night preceding the class discussion of the topic. The table in the next column provides the necessary values and formulae.

Formulae	Trial 1	Trial 2	Trial 3	Trial 4
Cube				
$A=6s^2$	$s=1$	$s=2$	$s=4$	$s=8$
$V=s^3$				
Cylinder				
$A=2\pi r^2+\pi dh$	$r=1$	$r=2$	$r=4$	$r=8$
$V=\pi r^2 h$	$h=1$	$h=2$	$h=4$	$h=8$
Sphere				
$A=4\pi r^2$		$\pi=3.1$		
$V=\frac{4}{3}\pi r^3$		$d=2r$		

In class discussion the teacher can show the students how to 'round off' the area and volume values to facilitate analysis of the data. The teacher should then ask students to derive a *ratio of area to volume* for each of the four calculations on the cube. Other students should do the same for the four calculations on the cylinder and the four calculations on the sphere. Why use these additional geometric figures?

Now the critical part. The teacher, utilizing the ratios, should lead the students to the discovery that volume increases at a faster rate than does surface area. The biological implications of this 'discovery' can now be explored intelligently by the students. In discussing the surface area-volume relationships care should be taken *not* to dwell exclusively on the implications of this principle for the inward movement or absorption of materials but *also* for its implications for outward movement or loss of substances from the

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cell. Both aspects have considerable importance in evolutionary theory.

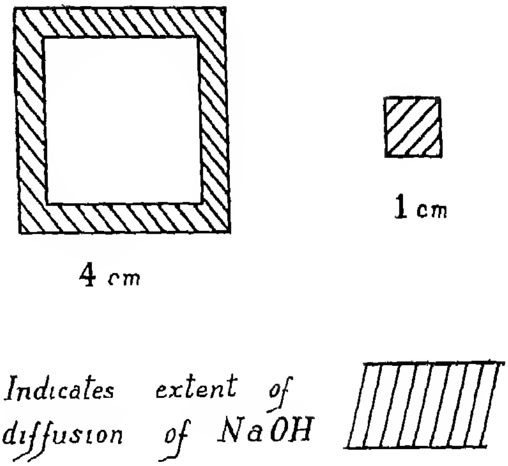
A novel demonstration to 'clinch' this topic that is simple, interesting and enjoyable utilizes the following

Prepare 200 ml of 3 per cent plain (non-nutrient, non-sterile) agar in a beaker Add to the agar 2 g of phenolphthalein powder and adjust to a slightly acid pH with HCl. Allow agar to solidify Remove agar chunk from beaker and carefully carve from it a 4 cm cube and a 1 cm cube. Place both cubes in a clean dry culture bowl or beaker

Pour a 1 per cent NaOH solution into the culture bowl until the cubes are covered. Let them stand for 10 to 15 *seconds* only and then quickly drain off the NaOH and remove the blocks to a sheet of wax paper. Take a clean dry scalpel or knife and cut each cube through the center into two halves.

Show the students the degree of diffusion of the NaOH solution into each cube as indicated by the bright red colour Does the observation support the deduction made from the mathematical calculations?

If it is difficult for your students to see the cross sections, thin centre slices may be taken from each cube and placed directly on to the overhead projector. The contrast between the degrees of diffusion in the 2 blocks can be clearly seen on the screen. If time and materials permit the teacher may ask the students to perform this exercise themselves.



Agar cube cross sections

Materials needed

Beaker 250 ml	Agar (plain)
Culture bowl	Phenolphthalein powder
Scalpel	Sodium hydroxide
Wax paper	Hydrochloric acid
pHydrion tape	
Balance	

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[This paper will also appear in *Misco Memos*, the commercial newsletter of Misco Biological, Inc., Ann Arbor, Michigan, U.S.A. Mr. Fordyce is the educational consultant for this firm The co-release of this article is with the permission of Misco Biological, Inc. —EDITOR]

General Science Curriculum for Higher Secondary Classes–II

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THE position of General Science at the higher secondary level in India has been described in an earlier paper*. The facts gathered were discussed in a Seminar at Varanasi, consisting of university teachers, science consultants from some states, science lecturers of some teacher training colleges and a small number of science teachers A summary of the proceedings of this seminar was reported earlier.†

The suggested sequence of major and minor concepts is as follows:

I. MATTER

A. *Scientists have propounded many theories for explaining the structure of matter and its properties.*

1. Dalton propounded a theory to explain the atomic nature of matter.
2. Atoms of different elements are different (atomic number).
3. Atoms of the same element are similar in proton number but may differ in that of neutrons.
4. Elements combine with one another under certain conditions to form new compounds.
5. The combining power of a chemical element when it unites with others to form a molecule is valence.
6. The free electrons of an atom determine its combining capacity with other elements.
7. Valence electrons take part in chemical reactions, in electrical condition and determine the characteristic properties of atoms
8. There are three main types of bonding. electrovalent, covalent and co-ordinate covalent.

B. *Chemists have classified various elements in a systematic manner.*

1. Mendeleeve classified chemical elements on the basis of empirical observations and propounded the periodic law.
2. The discovery of atomic number gave the Periodic Table a new strength.
3. The Periodic Table provides a useful means for organizing the chemistry of elements and aids in understanding such concepts as reactivity and valences and the predictability of properties.

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*General Science Curriculum for Higher Secondary Classes—*School Science*, 3 (2): 151-155, June 1964.
†News and Notes, *School Science*, 3 (2): 204, 205, June 1964.

C. *Chemical elements are divided into two broad classes*

1 Chemical elements are divided into two somewhat ill-defined classes called metals and non-metals.

2. Some elements occupying border line position are termed metalloids (As, Sb).

3. Metals are generally opaque, lustrous, capable of taking high polish, good conductors of heat and electricity and very often malleable, ductile and have a great tensile strength.

4. Because of their chemical properties, metals usually occur naturally in combination, and have to be extracted from their ores by metallurgical processes.

D *A chemical change giving rise to one or more new substances is called a chemical reaction.*

1. A chemical reaction can be promoted either by physical or chemical agencies.

2. There are four main types of chemical reactions—decomposition, combination, exchange reaction and rearrangement.

3. Chemical reaction is accompanied by energy exchange.

4. Speeds of chemical reactions can be changed by a catalyst, either inorganic or organic.

5. A substance which enters into and accelerates or retards a chemical reaction at molecular level and yet is removed at the end of the reaction is called a catalyst.

A positive catalyst accelerates, while a negative catalyst retards a reaction.

6. Catalytic processes have been found to take place in all living organisms.

II NUCEAR ENERGY AND TESTS

Nuclear Energy

A *The concept of elements, molecules and atoms underwent considerable changes in the past*

1. Ancient Indian and Greek philosophers had formed a concept of element.

2. Modern ideas about elements differ from those of the ancient

3. Dalton propounded a theory of the atom which was subsequently modified by Rutherford and Bohr.

4 Nucleus of an atom is surrounded by electrons orbiting in shells. They cluster as an electron cloud.

B. *Some elements are radioactive and give out radiations of various types*

1. Some heavy atoms are unstable.

2. These emit three types of radiations—alpha, beta and gamma rays.

3. These elements are known as radioactive elements.

4. Strong attractive forces hold the nuclear particles together within the nucleus.

5. The nuclear binding energies are very high.

6. Mass and energy are interchangeable according to the equation $E = mc^2$

C. *Fission and fusion are caused under certain conditions.*

1. All the atoms of an element contain the same number of protons.
2. The number of neutrons in an atom may be different; the difference gives rise to isotopes (illustrated by ordinary hydrogen and heavy hydrogen).
3. Uranium has three isotopes U^{234}, U^{235} and U^{238}
4. If U^{234} absorbs a neutron, it breaks into two almost equal parts. This process is known as fission.
5. Fission occurs easily in U^{235}, but not so easily in U^{234} and U^{238}.
6. In each fission process, two to three neutrons are given out which give rise to a chain reaction provided they are not lost.
7. The mass of the fission fragment plus the mass of the neutrons emitted is less than the mass of the U^{235} nucleus plus the mass of the colliding neutron. This difference in mass is converted into energy.
8. The fission of one kilogramme of U^{235} will evolve as much energy as about 2,000 tons of coal.
9. In the hydrogen bomb, the fusion of two deuterium nuclei into a helium nucleus produces energy.

Nuclear Tests

D. *Nuclear energy can be harnessed for useful purposes.*

1. Scientists are working at the controlled production of energy by this process.
2. A reactor produces nuclear energy at a controlled rate for industrial use.
3. India is constructing a number of nuclear power plants
4. Radioisotopes produced in a nuclear reactor find many useful applications in medicine, industry and agriculture

E. *Nuclear tests are harmful to man in many ways.*

1. The first use of nuclear fission was in the form of a bomb which was dropped on Hiroshima which produced great destruction of life and property.
2. The modern hydrogen bomb is many times more destructive than the first nuclear bomb.
3. The loss of life was due to the pressure blast, great heat generated and the radiation effects
4. The nuclear powers are carrying on periodical tests to improve their nuclear weapons.
5. These tests produce world-wide fall out of radioactive dust.
6. Radiation above the tolerable range causes sickness such as nausea, vomiting and fatigue.
7. Higher doses of radiation cause death of living things.
8. Doses above lethal range cause death of 100 per cent of population in 30 days.
9. Increase of radiation dose causes reduced life expectancy, genetic injury, haemorrhage and cancer.
10. Lethal dose range varies from one animal species to another.
11. Nuclear tests are detected by many means.
12. Scientists are making efforts to devise protection against these radiations.

III COSMIC RADIATION

A. Cosmic rays are charged particles which bombard the earth constantly from outer space.

1. Not much is known about the origin of cosmic rays
2. The particles entering the earth's atmosphere are called primary radiations.
3. The primary radiations reaching the earth's atmosphere interact with the atoms of air and produce secondary radiations.
4. These radiations have very high energy and penetrating power.
5. Studies on cosmic rays have helped many discoveries to be made about the nucleus of atoms and the forces within nuclei.
6. The path of the particles can be photographed with the help of the W.C. Chamber.
7. They can be detected by a Geiger counter and other counters.

IV COMMUNICATION

A. Electro-magnetic waves can be generated and detected.

1. Hertz discovered the generation of electro-magnetic waves
2. These waves can be detected by (a) coherer (b) crystals.
3. Diode and triode valves help in the transmission and reception of electro-magentic waves.
4. Directive antennae are used to beam the transmission in different directions.
5. Ionosphere helps in reflecting the short-radio waves which otherwise would escape in space.
6. Transistors have replaced valves.

B. Wireless helps in communication at short and long distances.

1. Wireless has been used by the police in communicating with each other.
2. Pictures are beamed across continents through radio-photo service.

C. Photo-electric effect has a wide use in communication.

1. Ejection of electrons from some materials as a result of irradiation with light is known as photo-electric effect
2. This effect is used in relays such as burglars' alarm and automatic opening of doors
3. Photo-electric effect is used in talkies and television.
4. Telstar has made world wide television possible.

V FOOD AND HEALTH

A. Carbohydrates, fats and proteins form the main parts of food

1. There are three main types of food: carbohydrates, fats and proteins.
2. Proteins are formed by the polymerization of amino acid molecules.
3. Amino acids are of two types. essential and non-essential.
4. Different animals need different essential amino acids.
5. Essential amino acids are not synthesized in the animal body. They have to be taken pre-formed.

B. Most of the chemical reactions inside a living system are catalysed by enzymes.

1. Enzymes are proteins with catalytic activity.

2. Enzymes are directly responsible for digestion of food, respiration, condition of nerve impulses, contraction of muscles, use of sunlight energy for synthesis of carbohydrates, clotting of blood, etc.
3. Enzymes can be extracted from the cells and their reaction studied in test tubes.
4. The enzyme activity is specific due to the presence of an active group known as prosthetic group.
5. Co-enzymes are chemical substances which are non-proteinous, but activate the reaction of enzymes.

C. *Certain chemical substances secreted by ductless glands, called hormones, are essential for various physiological functions.*

1. Hormones regulate the growth and activity of the tissues.
2. Hormones are found in all higher forms of life, animals and plants.
3. Most hormones are produced in endocrine glands.
4. Some important harmones in animals are produced by the pituitary, thyroid, adrenal, pancreas, testes, and ovaries.
5. Plants also produce hormones which are growth promoting and developing.

D. *Many microorganisms produce substances of great industrial value from simple materials (sugar, starch, cellulose) by the process of fermentation.*

1. All fermentation needs some microorganisms to carry out the reaction.
2. Enzymes present in the microorganisms are responsible for
3. Ethyl alcohol is produced by fermentation of sugars.
4. Some common fermentation processes take place in the formation of acetic acid, lactic acid, citric acid, etc.
5. In the large intestines of many animals, useful fermentation of food takes place.
6. Fermentation by undesirable microorganisms can lead to the production of toxic substances in the body.

E. *Many diseases can be now controlled by the use of antibiotics.*

1. Alexander Fleming first observed the destruction of certain bacteria in a culture by accidental mould contamination. He isolated the chemical substance and named it penicillin.
2. Antibiotics are substances of natural origin having antibacterial properties.
3. Antibiotics have been derived from bacteria, moulds, fungi, algae and a number of substances including plants.
4. Most of the antibiotics are toxic to bacteria as well as to man. Penicillin, streptomycin, chloromycetin, aureomycin are some common antibiotics.

F. *Many chemical substances are used for fighting diseases.*

1. Substances capable of killing or inactivating microorganisms are called disinfectants
2. Some common disinfectants are —quick lime, chlorine, iodine,

peroxide, bleaching powder and sulphur dioxide.

3. Treatment of disease by chemical means is called 'chemotherapy'.
4. Quinine, salvarsan, sulphanilamide, sulphadiazine, etc., are some common drugs which have saved many human lives.

VI WEATHER SERVICE

A *Weather service helps us to know about the weather in advance*

1 Various types of observation stations operate in different countries, some stationary and some non-stationary.
2. Observation stations record air pressure, temperature, humidity, direction and speed of the wind, height of the base of clouds, rainfall since last observations, visibility, amounts and types of cloud cover.
3. Weather maps are prepared by considering weather observations made simultaneously over a large part of the world.
4 Slow and steady ascending and descending motion of air in the atmosphere lead to the physical development or dissolution of clouds or rain and to variation in horizontal wind speed and in the formation of high and low pressure zones.
5. Weather service is available to farmers, aviators, ships and small sea craft.
6. Indian Meteorological Department issues weather forecasts by express telegram and by post to individual subscribers.
7 Variable degrees of uncertainty occur in weather forecasts.

VII. CHEMISTRY IN DAILY LIFE

A. *Man has used his knowledge of the science of chemistry in many industrial processes.*

IRON

1. Iron is a very important metal in the economy and growth of a nation.
2. Iron is extracted from its ore (haematite) in a blast furnace by roasting and reducing it The product formed is called pig iron.
3. Pig iron can be further processed to produce cast iron, wrought iron or steel
4 Steel is iron containing up to 1.5 per cent carbon and minor amounts of other elements some of which are unavoidably present.
5. In India big steel plants are located at Durgapur, Bhilai, Rourkela, Tata Nagar, Bhadrawati.

ALUMINIUM

6 Aluminium is mainly found in nature as 'bauxite'—an oxide ore of this metal.
7. Aluminium is obtained from 'bauxite' by purifying it to alumina and then reducing it by electrolysis.
8. The metal has many uses because of its unusual combination of properties—lightness, high tensile strength—readily shaped, and good conductor of electricity service at sub-zero temperature.

SULPHURIC ACID

9. Sulphuric acid is made from 'sulphur' or 'pyrites' by Lead Chamber or Contact Process by oxidation of sulphur dioxide.
10. Sulphuric acid enters into a number of chemical reactions.

11. Sulphuric acid finds extensive use in the manufacture of fertilizers from phosphate rock, in descaling steel, in making inorganic salts and acids, and in the manufacture of organic compounds.
12. The industrial growth of a country is indicated by the amount of sulphuric acid it uses.

CEMENT

13. Cement is a pre-burned mixture of powdered limestone and clay, which on absorption of water becomes hard like a rock.
14. A mixture of cement and sand is used as mortar
15. Concrete is hardened mixture of sand, gravel and cement.
16. Reinforced cement concrete (RCC) is obtained by using iron rods in the structure of concrete.

B. Chemists have built giant molecules, by combining smaller molecules, which are of a great commercial value and which have bettered the lives of men.

1. Polymerisation is the process of linking of many small molecules called monomers to make giant molecules called polymers.
2. Plastics are high polymers which also contain some fillers and have the property of being moulded in a desired shape. They have a very high molecular weight.
3. Plastics are usually resistant to chemical change but soften easily either by heat or some other treatment.
4. Some natural substances are plastic in nature—like rubber, gum, rosin, shellac, resins.
5. Natural rubber is a hydrocarbon with the empirical formula (C_5H_8) n, a polymer of isoprene Its molecular weight is very great 180,000 to 400,000.
6. Vulcanization is the process of heating rubber with sulphur to strengthen rubber and make it resistant to heat and chemicals.
7. Synthetic rubber is a high polymer made artificially.
   (a) Buna rubber is from butadiene and styrene—it can be vulcanized and is used for making tyres.
   (b) Neoprene is built from acetylene. It is stronger than natural rubber and more resistant to wear, heat, sunlight, water and chemicals.
8. Synthetic plastics are mainly of two kinds:
   (a) Thermo-plastic: those that repeatedly soften with heat and pressure. These are long giant molecules of cellulose, e.g., celluloid, cellophane, rayon, gun cotton, etc.
   (b) Thermosetting: which become hard on heating and are resistant to water, wear, chemicals, and do not burn, e.g., bakelite, urea, formaldehyde, casein plastic, etc.

C. Many of the high polymers have been used as fibres

SYNTHETIC FIBRES

1. Rayon viscose, nitro-cellulose and acetate are fibres obtained from cellulose plastics.

2. Nylon is a protein-like fibre that is strong, tough, slightly elastic and chemically stable. It is obtained by polymerization of certain organic acids and amines.

3. Other artificial fibres are

   Polyester fibres (dacron, terylene), polyvinyl fibres (orlon), polythene, etc.

D. *Explosives are substances that can undergo very rapid exothermic decomposition with the formation of more stable products.*

1. Explosives may be single chemical compounds, mixtures of explosive compounds or one or more explosive compounds with non-explosive material.

2. Explosion can be caused by heat, impact, friction or detonation wave from another explosion.

3. Explosions generally form gaseous compounds or in some cases gases and solids resulting in :

   (a) liberation of large amounts of heat and raising the products to a high temperature,

   (b) gaseous products having a volume far greater than that of explosives themselves which expand considerably and are capable of doing a great amount of work.

4. Some common explosives are :

   (i) Gun powder—a mixture of charcoal, sulphur and nitre. It is a common constituent of fireworks and gun cartridges.

   (ii) Mercury fulminate—prepared by the reaction of mercury, ethyl alcohol and nitric acid, is most sensitive to impact, friction or heat, mainly used as a detonator.

   (iii) Nitroglycerine is a colourless liquid obtained by nitrating glycerine. It is largely used in manufacture of dynamite and propellants.

   (iv) T.N.T. (trinitrotoluene) is prepared by nitrating toluene. It is used in shells, bombs and grenades.

   (v) Dynamite is nitroglycerine absorbed in porous mineral earth called keiselguhr also called dictomaceous earth. It can be safely handled.

   (vi) Some recent explosives are 'tetryl' and 'cyclonite'.

5. Explosives are used in mining, blasting and ammunition industry.

E. *Fuels are our chief source of energy for domestic and industrial purposes.*

1. Fuels may be solids, liquids or gases : wood, charcoal, coal, petroleum, natural gas, coal gas, water gas, producer gas, alcohols and atomic fuels are common examples.

2. Petroleum is a complex mixture of hydrocarbons. It contains aviation spirit, naptha, petrol, kerosine, grease, diesel oils, paraffin wax, etc.

3. By fractional distillation the various products are separated at different temperatures.

4. Heavier fractions of petroleum can be broken up into lighter or more

volatile fractions to make them more useful as fuels. This is called 'cracking'. (Use of anti-knocks and octane value.)

5. Gaseous fuels are acetylene, coal gas, producer gas, burshane, etc.

F. *Alloys are metallic mixtures or combinations containing two or more metals.*

1. Properties of alloys are usually intermediate between those of constituent metals but sometimes one or more property is manifested in greater degree than others.
2. By sufficient experimentation, an alloy with any desirable combination of characteristics may be produced.
3. Some modern alloys with special properties are:

   Bearing alloys, stainles steel tungsten alloy, titamin corrosion resisting alloys, low expansion alloys, magnetic alloys, thermocouple alloys, high temperature alloys, die casting alloys.

G. *Photography is the chemical process of the formation of an image on the photographic plate.*

1. Image formation in a camera needs a lens, screen and the shutter.
2. Image is focussed sharply on the screen by adjusting the distance of the lens from screen, and the diaphragm in the shutter regulates the light.
3. Silver halides undergo reduction on exposure to light.
4. On a photographic film, colloidal silver bromide suspended in gelatin is affected by light to form an invisible or latent image.
5. The latent image is developed by treating the film with a suitable reducing agent or developer (metol or hydroquinone or pyrogallol, etc.) which causes black metallic silver to form in the gelatin.

(To be continued)

Central Glass and Ceramic Research Institute

THE Central Glass and Ceramic Research Institute, Calcutta, was established in August 1950.

The main objectives of the Institute are:

1. Fundamental research having a bearing on different branches of glass and ceramics.
2. Standardization and testing.
3. General technical assistance to industry.
2. Dissemination of technical information.
5. Training of personnel for special work.

The main subjects of research at the Institute are glass, pottery, refractories and vitreous enamel.

PROGRAMME OF WORK

During the period of its existence, the Institute has given priority to problems having a direct bearing on industrial needs Its policy has been to concentrate efforts on a few projects and complete the investigations within a reasonable period, rather than spread its activities over a wide field. In following the above policy, the need for pursuing fundamental research which must be one of the aims of any

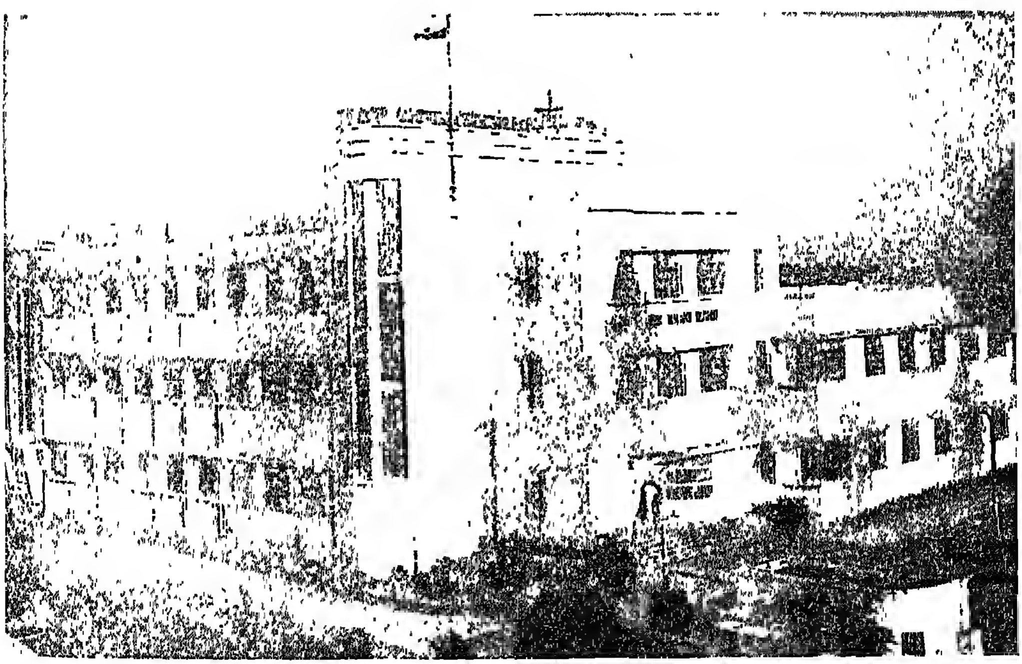

Fig. 1. Central Glass and Ceramic Research Institute.

research laboratory has been fully kept in view

Problems concerning the *industry as whole* are investigated *free of charge* The findings are made available to the industry and the public through discussions and publications. Where, however, an individual party submits a problem that requires special investigation, a reasonable charge is made to cover a part of the expenses borne by the Institute. General enquiries regarding information on the availability of raw materials, equipment, processes, etc., are attended to free of cost.

Full opportunity is provided to members of the industry to discuss their problems—such as the design of equipment and layouts—with the technical staff of the Institute. These discussions are kept confidential.

SOME OF THE IMPORTANT INVESTIGATIONS

Raw Materials

Although Indian raw materials are being utilized in the glass and ceramic industries for a fairly long time, precise and detailed information on the above has not been available.

Survey and assessment of raw materials for the glass and ceramic industries forms an important item in the programme of the Institute's activities. The raw materials of particular interest are : sands and sandstones, quartz, talcs, kyanite, pyrophillites, sillimanite, nepheline cyanite, Fuller's earth, bauxite, zircons, chromites, limestones, dolomites, magnesite, graphite, gypsum, vermiculite, diaspore, diatomite, clays.

SANDS, QUARTZ AND FELSPARS : It has been observed that several sands could be improved by simple sieving and washing. The improvement is spectacular in Travancore sands containing ilmenite, whose presence, in view of the high iron and titanium contents, would otherwise render them unsuitable for glass making. Abundant supplies of glass sands are available in practically every State. The quartz in some areas is so pure that it has attracted the attention of manufacturers of special optical glasses even in other countries. The Institute is well-equipped with appliances for the beneficiation of glass sands. Demonstrations of the techniques are often arranged for the benefit of the industry.

CLAYS. Investigations on the country's clay deposits have been in progress for the last about ten years, in collaboration with the Geological survey of India, and recently with the co-operation of the Indian Bureau of Mines and the Geological Departments of some of the States. These departments look after the field part of the work e.g., collection of samples, assessment of the extent of deposits, and transport facilities. The Institute examines the samples in detail for their properties and beneficiation, with special reference to their utilization in the industry.

The results of preliminary examination of several samples of clays have been published as a monograph on '*Indian Clays*' (Part I & Part II). The Institute has set up an experimental unit for washing of clays. Samples of clays are regularly examined for their washing characteristics particularly to determine the available quantity of fine-grained clay. The washed material is examined for physical

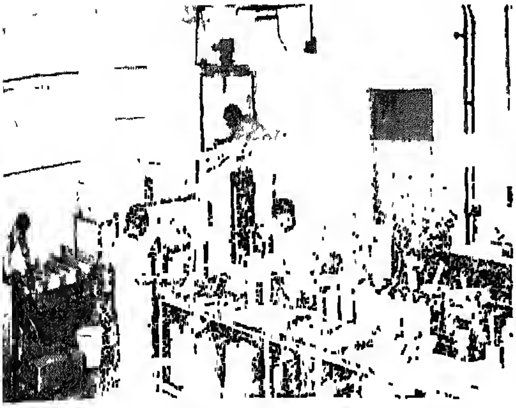

Fig 2 An Experiment Setup for Washing Clays

properties, such as plasticity, water of plasticity, drying shrinkage, dry strength-forming characteristics, firing range, firing behaviour and fired properties like colour on firing, firing shrinkage, etc

Suitable ball clays have so far not been located in the country and what are actually used in many places are a little more plastic clays. In order, to assist the industry in this regard, investigations were undertaken to examine if by some method the plastic clays available in the country could serve the same purpose. The results have been published for the benefit of the industry.

Recently due to the very rapid expansion of the refractories industry, bulk samples of several fire clays received from private parties and government organisations have been examined for their suitability for the manufacture of refractories, and in some cases compositions suitable for manufacturing operations were worked out for their industrial utilization.

TALC. Talc is extensively used in making a variety of ceramic articles. India possesses abundant resources of high grade talcs comparable in properties to those available in other countries. As a result of investigations, it was found that steatite insulators with very low dielectric loss could be developed out of Indian talcs.

Standardization

The value of standard specifications for attaining efficiency in manufacture and in improving and maintaining quality of products is well known. Their formulation requires detailed basic information on the performance of the raw materials and finished goods in actual use. Very little information was available in this regard, and the Institute undertook extensive laboratory investigations on the basis of which the Indian Standards Institution has prepared several standards. In addition, the work has been helpful in the analysis of the problems of the industry particularly the defects in the products. Some of the items on which the investigations were undertaken are : limestones suitable for the glass industry, penicillin vials, ampoules, sheet glass, laboratory glassware, railway signal glasses, liquid gold, wall tiles, fire clay refractories, porcelain articles, stoneware, earthenware, dinnerware, etc. In addition, some alternative tests were suggested, for instance, for the durability test of glasses and for the panel spalling test for refractories. The former has already been accepted for the Indian standards. A detailed comparative study was also conducted on testing methods used in several countries of the world for the evaluation of refractories.

Improvement in Quality

GLASS CONTAINERS : A wide variety of glass containers, constituting about

40 per cent of the total production of glassware worth about four crores of rupees, is used in the chemical, pharmaceutical, fruit preservation, soft and alcholic drinks, dairy, cosmetic and other industries which have expanded very rapidly during the last decade. Containers of inferior quality are detrimental to the interests of user trades and ultimately to the consumers. Complaints from consumers on the lower performance of some of the local products were investigated in detail. With the co-operation of producers and consumers, glass compositions suitable for the manufacture of glass containers for inks, distilled water, pharmaceutical products, mineral water, milk and preserved fruits, bear and gripe water have been worked out and these have been formulated so as to involve practically no change in manufacturing operations, thus avoiding interruption in the production schedule. Methods of testing the quality of containers before use, which are necessary to consumer industries in selecting suitable containers, have also been worked out. The results are being used by the industry and few complaints are now received from the consuming industries about the quality of glass containers. As a result of these investigations the import of glass bottles has been reduced considerably. The average annual imports during the period 1950-54 were more than 13 lakhs of rupees while during 1955-59 they were reduced to about 6 lakhs of rupees per year.

SAGGARS : In the pottery industry, saggars are used as containers for firing articles in the kilns. They are used over and over again, and consequently the cost of production of potteryware is appreciably influenced by the life of the saggars. It was learnt from the factories that the life of the saggars used by them was about 6 to 8 firings as against 20 to 24 obtaining in other countries. Compositions and technique of making durable saggars were worked out. Service trials conducted in the factories showed that the improved saggars could withstand 18 to 30 firings. Some of the factories have utilized these results which have been published.

OIL PRESSURE LAMP REFRACTORY HOLDERS : The mantles of oil-pressure lamps are held by refractory holders, most of which were till now imported. In the past, attempts to produce these holders in India were not altogether successful. Investigations were, therefore, taken up at the Institute and lamp holders were produced using indigenous raw materials, comparable in performance with that of the best imported articles.

PLASTER OF PARIS : Plaster of Paris is an essential material for making moulds in which the ceramic articles are formed. Plasters with varying properties are required for different purposes. Most of the factories produce their own plasters, but there was the problem of producing good plaster of uniform quality. After detailed investigations the Institute worked out the conditions for making good quality plaster of different types, e.g., for casting moulds, for jigger and jolley moulds, for high strength pressure moulds, etc. One of the processes was tried on a pilot scale at the Institute and some factories started manufacturing Plaster of Paris by utilizing the process developed at the Institute.

Glass Moulds: Glass moulds, usually made of metal, are an essential requirement of the glass industry and the quality and performance of the moulds determines to an appreciable extent the finish and cost of the glassware These moulds are generally supplied by small foundries and their quality is rather poor. Laboratory investigations undertaken at the Institute for determining the conditions of producing moulds of better quality have been completed and moulds made accordingly gave satisfactory performance when tested under actual operating conditions in some of the local glass factories The utilization of this process, however, presents a special problem, since in majority of the cases, the workshops attached to the glass factories or other foundries are not usually fitted for making the special moulds.

REFRACTORIES: (a) *Steel plant refractories*: In view of the expansion of the steel industry, the Institute was called upon to undertake a wide variety of investigations on the examination of raw materials, and comparison of the performance of Indian refractory products against specifications in practice in the USSR, Britain and Germany, the countries which are collaborating in establishing steel plants in the country, with a view to facilitating the use of indigenous products in these plants. Investigations were carried out on improving the quality of fire clay and silica bricks and blast furnace refractories.

(b) *Fire clay refractories*: In India bauxite is used in the manufacture of high heat duty fire clay refractories from low alumina fire clays. It was often reported that although the chemical composition of such refractories was normal, their performance as a refractory was not very satisfactory. This was investigated in detail and the causes for the poor performance were established. The results have been utilized in the industry.

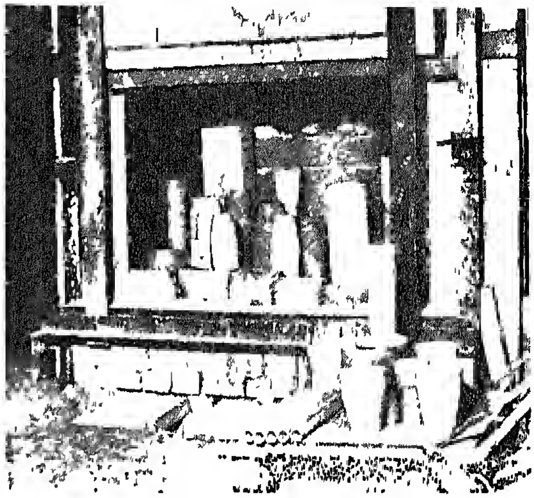

Fig 3. Furnace for firing of special refractories developed in the Institute

A process has been developed for improving the quality of fire clay refractories by the addition of suitable mineralisers. According to this method the use of bauxite can be eliminated, thereby reducing the cost of such refractories. Also, low alumina clays can be used in the manufacture of high heat duty fire clay refractories with properties better than the usual commercial products made with the addition of bauxite.

Investigations have also been carried out on the utilization of high alumina non-plastic clays, hitherto not much used, in the manufacture of super duty fire clay refractories suitable for blast furnaces and glass melting tank furnaces.

(c) *Spinel type refractories*: Investigations were carried out to determine the optimum conditions for addition of magnesite to bauxite to manufacture spinel type of refractories which might be suitable for use in the construction of rotary kilns for cement. It is learnt that such bricks are used in Japan in open hearth furnace roofs in place of chrome magnesite refractories.

(d) *Chrome-alumina refractories*: An investigation was taken up to see if chrome-alumina refractories could be developed from indigenous bauxite and chromite so that the same might be used in place of chrome-magnesite refractories Some laboratory trials have been made and work is being continued.

(e) *High alumina refractories* There is some demand in the country for high alumina (75%) refractories but these are not so far made in the country. Laboratory investigations have been completed on the possibility of manufacturing such refractories mainly from indigenous bauxite.

(f) *Hot face insulation refractories*: Hot face insulation refractories serve the dual purpose of an insulating material preventing heat loss from the furnace as well as a high temperature refractory which can be exposed to temperature of the order of 1500° or more. One or two firms in India manufacture such refractories in limited quantities but their scope is restricted.

A process has been developed at the Institute for the manufacture of hot face insulating bricks from kyanite. The properties of these bricks are similar to imported ones. The process has been utilized in setting up a new factory for production of hot face insulation refractories.

IMPROVEMENT IN LOCOMOTIVE HEAD LIGHTS: The Indian Railway Board requested the Institute to examine the possibility of reducing the spread of light from the locomotive headlights so as to ensure better illumination of rail tracks, either by changing the reflectors or by providing a system of lenses. A fairly simple and inexpensive method which would not involve any change in the present assembly of fittings, has been worked out by designing a special bulb as the source of light. On trials conducted in the workshops of the Eastern Railway at Jamalpur, it was found that at a distance of 1000 feet the intensity of illumination increased to 0.7 foot candle from the present maximum of 0.25, and at 1500 feet it was 0.3. Detailed observations made at different heights from the track, beam angle and distance from the reflector showed that almost at all stages, intensity of illumination increased two to three fold. The results have been published.

APPLICATION OF STATISTICAL METHODS IN QUALITY CONTROL: Statistical methods although now universally recognised as an important tool in maintaining and improving the quality of production, have not been extensively used in the glass and ceramic industries. One of the allegations levelled against the manufacturers of glass containers employing hand-operated forming machines was that the variations in size and capacity of the containers were too wide for successful operation of automatic filling machines. As a result of statistical studies it was established that uniformity in weight and capacity of the containers could be maintained with the existing equipment and facilities by

exercising better supervision on the operations and by employing quality control charts.

The technique was also utilized to control some of the important properties of heat insulating bricks made from waste mica, namely porosity, bulk density and crushing strength—factors which are important in determining usefulness in actual performance. It was shown that quality level could be maintained above the consumers' specification limits.

Evaluation of some of the important properties of glass containers and ceramic wall tiles, produced by different manufacturers was also undertaken.

SUBSTITUTES OF IMPORTED AND SCARCE RAW MATERIALS

One of the important fields of activity in the programme of the Institute is concerned with the finding out of substitutes for raw materials essential to ceramic industries. Amongst such imported raw materials, borax, antimony oxide, tin oxide, cobalt oxide, selenium, vermiculite, soda ash may be specially mentioned. Apart from the success that has been achieved in replacing some of these the progress of work has led to some important fundamental scientific investigations.

Borax

Borax is used as a flux in vitreous enamelling, glass and pottery industry.

(a) Boron-free vitreous enamels. The annual production of vitreous enamelling industry is valued at about two crores of rupees. It has a fairly wide range of production which includes articles used as advertisement signboards and information panels, and also as hospital and household utensils by an appreciable section of the population. One of the main ingredients of vitreous enamels is borax, for which no suitable source has so far been located in the country. The industry is, therefore, entirely dependent on imported borax. The Institute has worked out enamel compositions free from borax and any other boron compound by utilizing indigenous raw materials. Extensive trials in enamelling factories have shown that the performance of boron-free enamels is equal to that of the boron enamels

No change or modification in the existing industrial practice is necessitated by the introduction of these enamels. Apart from an annual saving of about 5 to 6 lakhs of rupees by way of foreign exchange and assisting the utilization of indigenous resources, the industry will become independent of imports of borax. The work is covered under patents and the process has already been leased out to a firm in India for commercial utilization.

(b) BORON-FREE GLAZES: Lead oxide and borax are main ingredients of glazes used in the manufacture of earthenware. Of these, lead oxide is manufactured in the country. An investigation has been undertaken to develop suitable earthenware glaze compositions without the use of boron compounds.

Antimony Oxide

Antimony oxide is an imported material which is used in white enamel as an opacifier. The Institute has developed antimony-free white enamel both of the boron-free as well as boron-bearing types. In addition, the colour of the antimony-free enamels is almost neutral to bluish white and no special colour stabilizers like phosphate, etc., used with other usual enamels are necessary for

avoiding yellowish discoloration These enamels have been successfully tried under factory conditions and wares coated with them have been marketed in limited quantities. The process is ready for commercial utilization.

Cobalt Oxide

In ground coat enamels cobalt oxide has so far been considered essential for developing the necessary adherence between the enamel and the iron. Cobalt oxide is an imported material and is also quite costly. The cobalt-free enamels developed at the Institute have proved to be quite satisfactory and show adherence comparable to that of the cobalt bearing compositions. These enamels have proved successful in performance under factory conditions and some articles manufactured by using cobalt-free ground coat enamels have also been marketed.

Selenium

(a) Red glass bangles: One of the biggest cottage industries in the country is the glass bangle industry concentrated at Firozabad (situated about 20 miles from Agra in Uttar Pradesh). It provides, in one way or the other employment and livelihood to some seventy thousand people. The total annual production of glass bangles is valued at three to four crores of rupees. Red bangles are particularly popular and constitute about 50 per cent of the total production. Selenium is employed as the colorant. In view of the world shortage of selenium, the industry faced great hardships. The price of selenium in Firozabad had risen as high as Rs. 300 per pound compared to the pre-war price of Rs 8 per pound. At times it was not available even at that price.

The total amount of selenium used at Firozabad is valued annually at about 15 lakhs of rupees To relieve this important cottage industry of its dependence on imports, the institute conducted detailed investigations to eliminate the use of selenium. Extensive trials conducted and demonstration given at Firozabad, in which local artisans and equipment were employed, proved quite successful for producing most of the red bangles without the use of selenium.

(b) Red signal glasses: Selenium is also used for manufacturing red signal glasses used in railways, road and air traffic control. The Institute has developed processes for producing such glasses without the use of selenium. On a comparative study, these signals were found satisfactory in performance when used in railway yards. The question of their official adoption by the Indian Railways is under consideration.

(c) Conservation of selenium for decolorising glass: Besides being a red colouring agent, selenium is also used as a decolorising agent in the manufacture of colourless glassware. The quantity of selenium imported for this purpose is quite substantial.

Soda Ash

Most of the soda ash required in glass manufacture in India is imported. Due to inadequate supplies of this material, several glass factories have sometimes had to curtail production

The Institute was asked to investigate the possibility of substituting soda ash by saltcake available in Didwana, Rajasthan, where an annual production of about 7,500 to 8,000 tons was estimated. It was found that in some types of glass-

ware (such as amber glass), natural salt-cake as such without refining could replace soda ash up to 25 per cent. In the production of amber glasses, saltcake should be utilized even otherwise, since it eliminates the use of imported sulphur also. By using saltcake, the cost of production of amber bottles is reduced. It was later found out that the natural saltcake would not be available in sufficient quantities and could not be spared for the glass industry.

INVESTIGATIONS INTO THE PRODUCTION OF IMPORTED ARTICLES

In spite of the appreciable expansion of glass and ceramic industries after World War II, quite a number of articles of varied nature are still imported. In addition to finding out substitutes for imported raw materials an important activity of the Institute is to investigate the possibility of manufacturing such articles in the country from local raw materials.

Signal Glasses

Several types of signal glasses are used on railways and in road and air traffic control. Although imports were not very large, signal glasses are essential items and their production within the country was of vital importance. The Institute has worked out processes for manufacturing them by utilizing indigenous raw materials as for as possible. Extensive trials conducted in railway yards, have shown that the glasses are satisfactory. Some manufacturers are already producing them.

Sun Glasses (goggles)

Sun glasses are important for a tropical country like India, and these are imported in large quantities. The essential requirement of the glasses is that they should cut off the ultra-violet and infra-red portions of the spectrum, which are injurious to the eye, and should reduce transmission in the visible region only to the extent of preventing glare.

About a dozen brands of imported sun glasses, available in the market, were examined. Several of these were found to be unsuitable for Indian conditions due particularly to their inability to absorb heat rays effectively. After detailed investigations, compositions for making these glasses, which will meet most of the requirements expected of a good sun glass under Indian conditions, were worked out at the Institute. However, their production has not so far been undertaken in the country.

Eye Protective Glasses Used in Welding Operations

In welding operations protective glasses are essential for the eyes. These glasses are wholly imported and although the volume of import is worth only about two lakhs of rupees per year, the requirement is essential. The Institute has developed glass compositions suitable for producing them. One of the big consumers in India is trying to get them made according to the Institute's findings.

Chemical Porcelain

The Institute has successfully worked out processes for manufacturing chemical porcelain such as crucibles, dishes, funnels etc., used in research laboratories from indigenous raw materials. These were tested in several chemical laboratories and were found to compare favourably with some of the best imported articles.

The cost of production according to the Institute's process is expected to be lower than that of the imported products.

Dental Porcelain

Artificial teeth worth several lakhs of rupees are annually imported into the country. They are made from porcelain and plastics, but because of the superior abrasion resistance and durability, the porcelain teeth are preferred. Investigations on production of these were undertaken and the samples produced have been found to be satisfactory with regard to abrasion, translucency, thermal shock, resistance to acids and colour by the dental profession in India.

Porcelain Parts of Automobile Spark Plugs

Spark plug forms an essential part of the automobile engines. About 1,500,000 spark plugs are imported annually. There are two firms in the country who make the metal parts locally and assemble the finished spark plug by using imported porcelain parts. It was desired by the Tariff Commission that efforts should be made to make the porcelain insulator in the country. A few hundred spark plugs made at the Institute were subjectd to performance trials which proved satisfactory for the type of automobiles used in the country.

Enamal Coated Resistors

A wide varicy of resistors, coated with vitreous enamels are used in electrical industries. These were so far either imported or were manufactured by coating locally made resistors with imported enamel.

Investigations were taken up to work out enamel compositions suitable for coating resistors. Suitable compositions were developed possessing the necessary thermal shock resistance and other essential properties.

Copper Enamels

The Institute has successfully developed processes for enamelling copper metal for making dials (telephone dials, water-meter dials).

Pink Enamels

Investigations were undertaken on the problem of producing pink coloured enamels so far made by using gold pink, chrome-tin pink, or selenium-cadmium pink stains which were very costly and had to be imported. A process was successfully developed for producing low cost pink enamels without the use of the above ingredients.

White Enamel For Direct Application on Steel

Investigations have been in progress to obtain white vitreous enamels which can be directly applied on steel so as to eliminate the use of ground coal enamels and to effect economy in the cost of production and conservation of materials. A number of white enamel compositions as well as the techniques of metal treatment so as to receive the enamel directly have been evolved which have given promising results. The surface of the enamelled articles is fairly glossy and is free from pin holes, and possesses adherence comparable to commercial ground coat enamels.

Enamel stains are essential for making coloured enamels and have so far been entirely imported. Their annual consumption has been estimated to be worth about rupees 10 lakhs

Investigations were carried out for producing these stains by using indigenous raw materials as far as possible. Manufacturing details of about 20 enamel stains have been worked out.

In addition, investigations have been in progress on jewellery enamels, acid resisting enamels, and cast iron enamels.

INVESTIGATION ON THE PRODUCTION OF NEW ITEMS OF SPECIAL USE

Foam Glass. Foam glass is a unique, lightweight thermal insulating material. It is essentially glass expanded about twelve to fifteen times with a multitude of non-communicating cells, resembling more or less the structure of a honeycomb. It combines rigidity and moderate strength with lightness and high thermal insulating efficiency. Being fire and rot-proof and impervious to moisture and vapours, foam glass does not, unlike cork and many other insulating materials, deteriorate during use.

Foam glass is being manufactured in USA, USSR, and a few other countries where the details of the processes are closely guarded secrets. The product is extensively used in the building, air-conditioning and cold storage industries, as well as for insulating hot and cold pipes and tanks, used in the chemical and such other industries. The use of foam glass contributes to indoor comfort and in modern buildings to a substantial reduction in the costs of heating or air-conditioning.

Because of the importance of foam glass in a tropical country like India, the Institute had undertaken investigations on the problem. The processes for its production have been worked out successfully and have undergone pilot trials. India's requirements of such materials, including cork slabs, glass wool and expanded plastics are quite large and at present all of them have to be imported. For instance, the imports of cork slabs alone, during 1955-56, were valued at nearly 50 lakh rupees, obtained mainly from Portugal.

The process developed at the Institute is covered under patents and has been leased to a firm in India for commercial utilization.

UTILIZATION OF WASTE MATERIALS

Mica

HEAT-INSULATING MICA BRICKS. In the production of mica about 15 per cent is recoverable as saleable material; the rest is considered as waste. In the course of years, this has resulted in huge accumulation of waste mica in the fields. To assist the country to find uses for waste mica, the Institute has worked out processes for making heat-insulating materials extensively used in industrial furnaces and other installations. Hitherto these heat insulating materials were being produced mostly from vermiculite, which was imported into the country principally from Canada, USA and South Africa. Trials on industrial furnaces have confirmed that the performance of mica products developed at the Institute is comparable with that of vermiculite bricks.

By utilizing the Institute's process two factories, one at Bhilwara (Rajasthan) and the other at Chanch (Bihar) have started producing and about four to five lakh bricks have already been supplied to the Bhilai Steel Project as a substitute for diatomite bricks This work apart from saving foreign exchange on the import of these materials and on vermiculite, has given rise to an entirely new industry

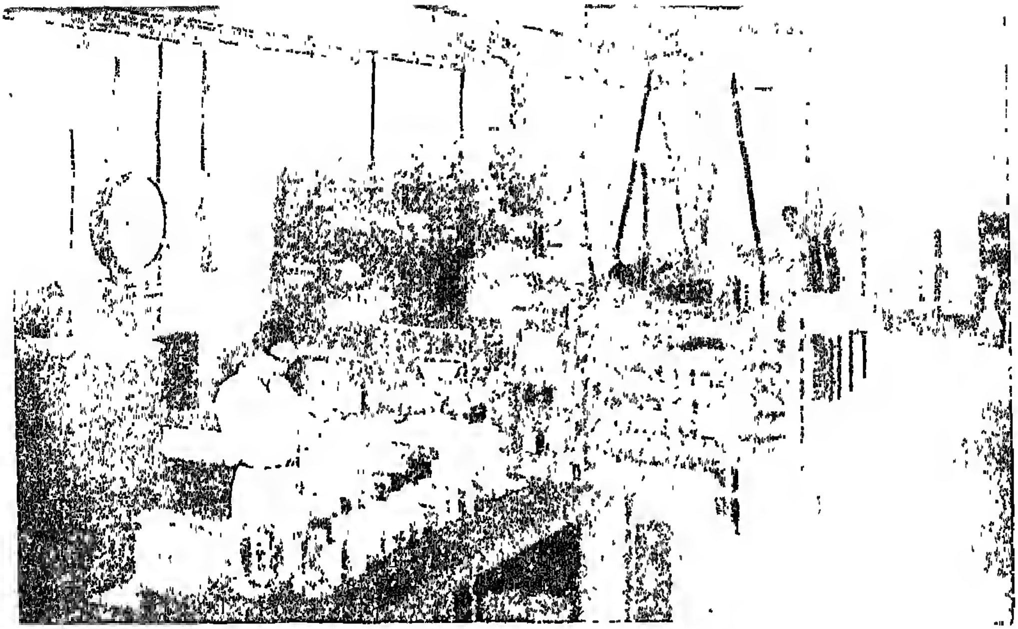

Fig 4. Section of the Institute engaged in research on the utilisation of waste mica.

in the country and will provide increased employment.

Wet grinding of mica: The wet grinding of mica is a special process by which mica is reduced to a fine powder without losing its gloss and other important properties. It is manufactured in USA, England and a few other countries where the details of the process are closely guarded secrets. The product is extensively used in the paint, rubber and wall paper industry. The Institute had undertaken investigations on the problem and has been successful in developing a process.

Samples of wet ground mica have been tested extensively by the paint and rubber industry in India. One rubber manufacturer has been obtaining the material from the Institute's pilot plant and a few foreign parties have also expressed their interest for exporting the product.

(c) Mica in paints: Investigations were undertaken on the utilization of mica powder in manufacturing various types of paints. Paints incorporating mica have generally shown better corrosion and heat and abrasion resistance and have longer life.

Assam Sillimanite

Massive boulders of sillimanite occurring in Assam are, after being sawn into blocks and other shapes, used in the construction of glass melting furnances. During the process of sawing a substantial amount of fine material is obtained

Investigations were carried out to utilize this material and processes were developed to manufacture glass house refractories from it. Further, it has also been successfully employed in place of kyanite in making good saggars. Kyanite has to be calcined at the high temperature prior

to use and for want of such kilns several pottery factories could not utilize the work done at the Institute on saggars where kyanite was to be used.

FUNDAMENTAL RESEARCH

The selection of problems for fundamental research has been generally confined to those having a bearing on the glass and ceramic science and technology.

In the field of glass, the investigations have been concerned with the origin of colour in glasses coloured by selenium, copper, manganese and vanadium; the fields of glass formation and development of new compositions and a study of the chemical, physical and electrical properties of the resulting glasses; and the thermal expansion of glasses.

It is generally believed that the origin of colour in copper-red glasses is due to the colloidal particles of metallic copper. The work that was done at the Institute on the production of copper-red colours led to several observations which could not be explained on the basis of the above view. On a detailed study of the available literature and of the experimental results obtained, it has been postulated that the colour in such glasses might possibly be due to the absorption by particles of cuprous oxide of colloidal dimensions which are themselves red in colour. By applying X-ray methods and by studying transmission in visible region, considerable experimental evidence has been collected in support of this view By actually preparing colloidal cuprous oxide, hitherto considered difficult, and by examining the nature of the colloidal particles further support has been added to the proposed mechanism of the colour formation. Some recent publications on the origin of colour of some ancient glasses also seem to support the newly proposed mechanism. In this study it has also been observed that the supposedly feeble colouring power of the cupric ion present in glasses, is fairly high. The belief that for the production of copper ruby glasses, the presence of tin was essential has not been found to be correct since bright copper red glasses have been obtained without incorporating tin in the glass batch.

Detailed spectrophotometric and magnetic studies on glasses containing colouring metal ions, Ti^{3+}, V^{3+}, Cr^{3+}, Mn^{3+}, Fe^{3+}, Fe^{2+}, Co^{2+}, and Cu^{2+}, were carried out. On the basis of the results obtained, ideas on the origin of colour in relation to composition and structure of glass have been developed. Measurements of paramagnetic susceptibility of some of the glasses containing these ions were carried out and oxidation-reduction equilibrium in the glasses was studied.

Absorption characteristics of photo-oxidised Mn^{3+} and photo-reduced V^{2+} ions as determined on solarised glasses were observed to be different from those of normal ions and the results have been explained in the light of the ligand field theory

Investigations on the fields of glass formation have been carried out by the introduction of titanium oxide in the Na_2O-CaO-SiO_2 system and properties such as durability, viscosity, surface tension, thermal expansion and softening point of the glasses obtained, have been determined.

Glasses were prepared in the systems containing PbO, Al_2O_3, P_2O_5 and B_2O_3. Interesting combinations of different

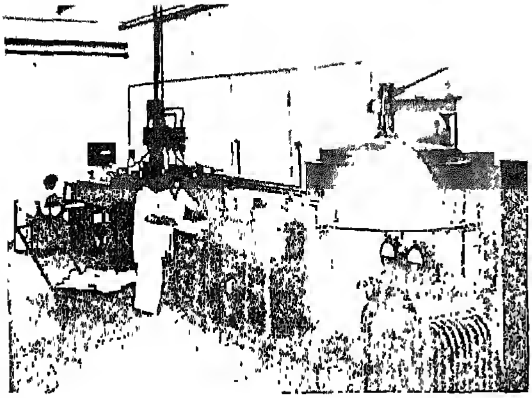

Fig. 5. Optical glass pieces being taken out of the furnace after fine annealing.

Delhi, Physics Department of the Delhi University, and the Ordnance Establishment of the Ministry of Defence, Dehra Dun, the latter being the biggest consumer in the country, and were found to be satisfactory in all respects

In view of the successful pilot plant work without any collaboration of the foreign manufacturing firms, the Government of India decided that optical glass should be produced at the Institute. Accordingly, a commercial plant with an annual capacity of about ten tons which will more than meet the present requirement of the country has been put up at the Institute. The essential equipment and furnaces were designed and fabricated by the Institute. Further, operatives had also to be trained, for this being an entirely new undertaking, no trained personnel were available in the country.

PRODUCTION OF SPECIAL GLASS AND CERAMIC ARTICLES

A number of glass and ceramic articles are used as components of equipment or as accessory materials during manufacture of other articles, e g , pyrometer sheaths, refractory tubes and plates, combustion boats, glass electrodes for pH meters, enamel stains, and ceramic colours for decoration of potterywares. The supplies of these were mostly met from imports. While engaged in investigations on examining the possibility of manufacturing imported articles in the country, the Institute had worked out methods for producing several of these but their total demand in the country was not large enough to induce somebody to undertake their production However, they were indispensable to scientific institutions, technical laboratories and industry and for want of timely supplies work had often suffered. In order to render assistance in this regard, the Institute had been supplying these articles to a limited extent. But the requests for supplies increased considerably and in order to extend the scope of this service the Council of Scientific and Industrial Research have sanctioned a scheme for their regular production at the Institute It may be mentioned that this activity will be in the nature of assistance. In fact, as soon as manufacture of any of the items is taken up by a firm in the country, that item will be dropped from the scheme. A start has already been made for the production of the above items at the Institute

TECHNICAL ASSISTANCE RENDERED

During the period 1954-63, assistance was rendered in about five thousand cases covering a wide range not only of subjects but even categories, such as information regarding the availability and suitability of raw materials, installation of equipment and furnaces, improvement in quality, operational difficulties, examination of finished products, com-

ments on designs, lay-outs, machinery, etc. Amongst the special investigations undertaken on behalf of the factories, mention may be made of peeling of glazes, shattering of sanitaryware, utilization of waste obtained in clay washing, special compositions for stoneware bodies, appearance of black spots in earthenware and prevention of stones appearing in glass melting.

CGCRI BULLETIN

Dissemination of information is one of the functions of the Institute. To perform it efficiently, the Institute publishes a quarterly scientific bulletin in which the results of research conducted in the laboratory are incorporated. In addition, summaries of important researches done elsewhere are also given. Information in regard to availability of raw materials and equipment, technical information on processes and operations, statistics relating to production, exports and imports, and topics of current interest are also included.

During the ten years of its publication, the bulletin has been well received and is widely subscribed by the industry, universities, technical institutions and Government Departments and enjoys a fair circulation in other countries, where its contents are selected for reprinting in glass and ceramic journals. It is on exchange with practically all the important journals of the world on the subject.

SUMMING UP

During the several years of its existence, the guiding principle in the industrial research activities of the Institute has been to make the country self-sufficient in essential raw materials and finished goods by improving the quality of the existing production, initiating manufacture of hitherto imported articles, assisting in locating new sources of raw materials, finding out substitutes for essential imported raw materials and finished goods and of making the industry fully conscious of the application of science and scientific approach to the solution of industrial problems. In the fields of fundamental research it has endeavoured in accumulating knowledge which will help better understanding of some aspects of glass and ceramic science and technology.

Classroom experiments

TRANSMISSIBILITY OF FLUID PRESSURE

PASCAL'S law states, that *the pressure exerted anywhere in a mass of a confined fluid is transmitted by the fluid in all directions, so as to act with undiminished force per unit area and at right angles to the surface exposed to the fluid.* That liquids transmit pressure equally in all directions according to this law can be demonstrated by the following simple experiment.

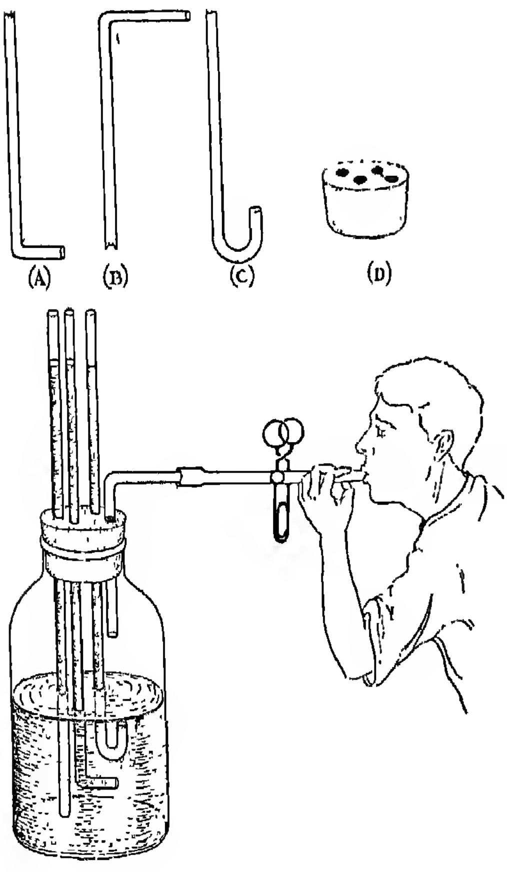

Fig. 1.

Take a bottle and four glass tubes of equal diameters. Bend three of them as shown in Fig. 1. Take a rubber cork to fit the neck of the bottle and bore four holes in it. Now, insert the four tubes into the cork (if you find difficulty in inserting the tubes into the cork, dip the tubes into water and try). Fit the cork to the bottle which is partly filled with coloured water. Keep three tubes (the straight, the L-shaped, and the U-shaped) at different levels of the liquid in the bottle as shown in Fig. 2. The fourth tube (b) which is used for blowing is kept with the end above the level of the liquid as shown in the figure. Attach a piece of rubber tubing to the end outside the bottle and fix a pinch-cock there. Open the pinch-cock, blow some air into the bottle and close. The external pressure, thus exerted in the liquid by your blowing causes the liquid to rise in all the three tubes. You will observe that the level of the liquid is the same in all the three tubes though the tubes are of different shapes and placed at different levels. The purpose of making different shapes of the tubes is to show that the liquid pressure is equally transmitted in all directions. In the L-shaped tube (a) the pressure is exerted in the horizontal direction: in the U-shaped tube (c) the pressure is exerted in the downward

direction and in the straight tube the pressure is exerted in the upward direction. Hence by performing such a simple experiment you can easily verify Pascal's Law

The practical applications of Pascal's law are apparent in pneumatic tyres, hydraulic jacks, hydraulic brakes, hydraulic presses, pneumatic drills and air brakes.

M.N. KAPOOR

AN EXPERIMENT FOR THE STUDY OF THE PATH OF A PROJECTILE

A WATER jet coming out of a nozzle would follow a straight horizontal path in the absence of an accelerating field. In actual practice, the gravitational field's presence affects the shape of water jet. With the help of a fine nozzle and an arrangement to adjust the nozzle horizontally and at different elevations, the characteristics of the water jet can be studied against a graph background.

A simple arrangement to set up the experiment is shown in Fig. 1. The depth of water jet, when its shape is maintained by regulating the flow of water, can be read on the graphic board at the points 1, 2, 3 and 4 lying in the horizontal plane containing the axis of the nozzle, and marked so that the distance between them is the same as the distance between the nozzle's end and the point 1. From the data collected with two or three shapes of the jets, it can be shown that the depths d_1, d_2, d_3, d_4 of the jet at marks 1, 2, 3 and 4 are in the proportion 1, 4, 9 and 16 respectively. This leads to the conclusion that the jet's path is a parabola.

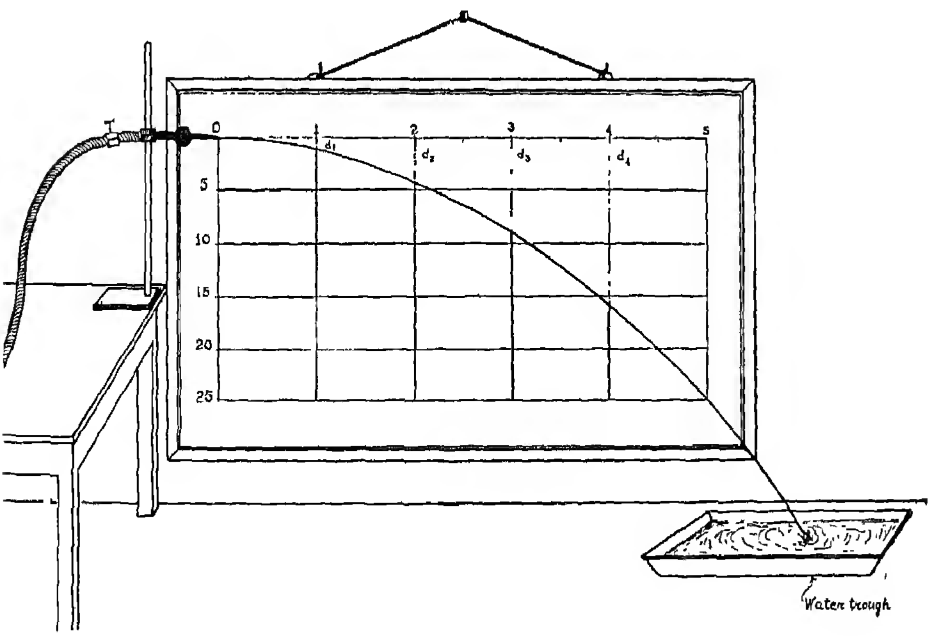

Fig. 1.

By varying the elevation of the nozzle as in Fig 2, it can also be shown that the distance reached by the jet is different for different elevations and is maximum for 45°.

Y-axis of the graphic board must be made vertical using a plumb line To keep the nozzle in position, a good laboratory stand with clamps for fine adjustment will serve the purpose The flow

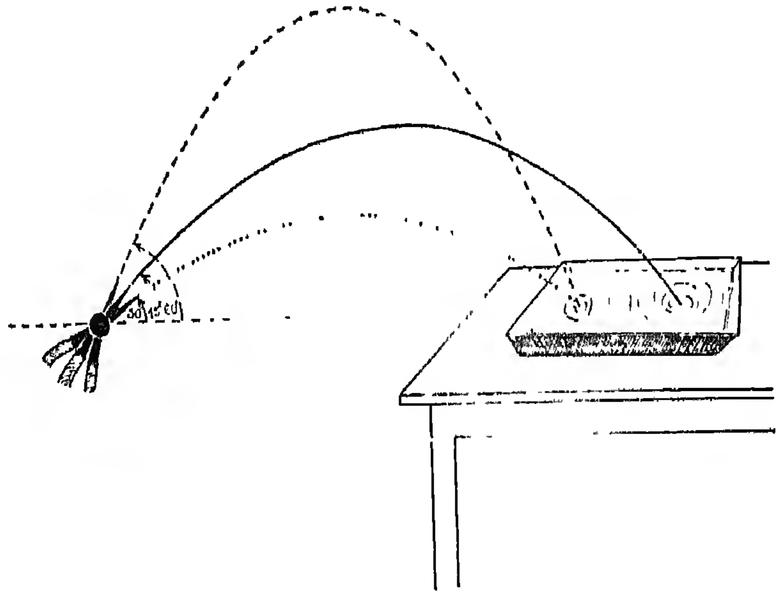

Fig. 2.

The nozzle supplied by any medical store for use with enema box, if it has a uniform bore, can be used for the experiment A jet drawn carefully from a glass-tubing can also serve the purpose. The shape of the jet can be varied by controlling the flow of water through the nozzle by attaching it to a rubber tubing having a pinch-cock arrangement.

of water can be regulated by using a constant flow device. The water jet can be made distinct by colouring the water red and making the background green with white lines to mark the fine graph. A large size water trough should be used to collect the water falling in the form of jet.

K.J. KHURANA

Science abroad

Teaching of Biology in Eight-Year and Middle Schools of U.S.S.R.

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BIOLOGY is the study of life. An acquaintance by the students with the general laws of life processes in the plant and animal kingdoms, with the essence of life and the various forms in which it manifests itself, helps them in forming a scientific and realistic outlook. A correct scientific understanding of the phenomena of nature frees one's mind of superstitions and prejudices.

In our country special attention is paid to the formation of the personality of the future citizens. Speaking in general, a knowledge of biology is a must for every cultured civilized man. Obtaining this knowledge in school the students share it with the people at home and their relatives. They thus become agents in spreading this knowledge among the various strata of the population.

At present, the growth and development of biology in the world is very rapid. It is becoming more and more related to medicine, agricultural sciences, forestry (silviculture), chemistry and even technology (bionics, cybernetics). Apart from the theoretical knowledge of interpeneration of and enrichment of sciences, the possibility of practical application of the data from biology in various fields of agriculture (cultivation, animal husbandry, veterinary and so on) is very large.

One of the basic principles, in the teaching of biology (as is also the case with other subjects) in the middle school of U.S.S.R. is relating science with life and preparing the students to do work useful to the society. The process of learning biology in school is closely related to practical work. In the middle school the students attain one of the industrial qualifications including specialization as animal husbandry assistant, field crop growing assistant, assistant in the agro-laboratory and so on, thus enabling them

* Prof. (Mrs.) Sazonova was a member of the Unesco Planning Mission of Experts on Science Teaching which stayed in India from January to March 1964.

to be immediately absorbed into work useful for the society.

Biology is taught to all students as a part of general education. The study of nature starts from the first year of schooling. The little student learns to observe seasonal variations in nature, to compute a calendar of the phenological observations and of weather; gets to know the structure of trees and about the important varieties of local trees. Often, the textbooks are devoted to descriptions of natural phenomena, wild and domestic animals, and plants. The students gather many biological facts on their excursions into the field.

In class IV, a systematic course on 'Natural Science' is introduced. It serves as a preparatory course for a number of subjects belonging to the natural science series (biology, geography, physics, chemistry) and hence special attention is paid to it. In this course the students learn about plants, animals and agriculture, of tundra, forest, steppe and desert zones in nature; obtain their first introduction to the structure of human body, the fundamental rules of hygiene and health. The course on 'Natural Science' is taught according to a special textbook.

In the middle school a systematic study of a course in biology is conducted from Classes V to IX. It falls naturally into different divisions (which are closely related to one another): botany (classes V-VI), Zoology (classes VI, VII), anatomy, physiology and hygiene of man (class VIII) and general biology (class IX). Teaching of these disciplines is in accordance with separate textbooks and manuals. In all the divisions of the course in biology, while stating any point, the close relationship between the questions under consideration and practical activity of man, national economy and public health, is shown. The teaching of botany in classes V and VI (class V, 70 hours; class VI, 49 hours) acquaints the students with the fundamental laws of the structure and life of plants. Special attention is paid in the formulation of basic concepts in the minds of the students, for instance · cellular structure of plants, plant organism as a single (harmonious) unit; individual and evolutionary development of plants; the relation between organisms and the medium of habitation or harmony between an organism and the conditions under which it lives. The teaching of botany is done in such a way that the students understand the close relationship of this scientific discipline with practical agriculture, and at the same time develops the skill of cultivating and looking after plants. It is very important to make the student understand the biological significance of various agro-technical measures and practices.

Zoology is taught in class VI (21 hours) and class VII (70 hours). A review of the animal kingdom is given in the following ascending order: invertebrate animals—simple Coelenterata, worms, Apoda (cylydnical, parasitic tape-worms and round worms) molluscs, Arthropoda, vertebrate animals -fishes, amphibians, reptiles, birds and mammals. In describing the animals, special attention is paid to those which are most important in the household (insect pollinators, domestic insects, fishes, pig-husbandry, fur-bearing animals and so on), those which bring about significant damage to economy (insects which are harmful to agriculture, forestry) germs which

cause diseases, (malaria parasite, parasitic worms) and those which are carriers of the latter (Arthropoda—carriers of the germs of diseases. mites and ticks, malaria mosquito, true lice, flea, house flies and others).

The process of study of zoology helps the students in understanding the organism of animal as a harmonious unit, the relation between animals and the conditions of life, the individual development of animals and the evolutionary development of the animal kingdom on earth. One of the topics included for the course is the changes in animals, brought about by man and the raising of new breeds of farm animals.

The study of zoology is also closely related to labour education. Practical experiments are done on destroying insects, pests, etc., which are harmful to agriculture and forestry; on bringing up rabbits, domestic birds and other animals taking the local conditions into consideration.

The class VIII students study anatomy, physiology and hygiene of man (70 hours). This course, besides imparting knowledge on the structure and functions of the human organism, develops basic hygienic habits in the pupil, which help in the maintenance of their health and conservation of energy. (In this division of biology the beneficial influence of physical labour and sports on the life activity of individual systems of the organs of man as well as on the human organism as a whole, is shown. The teaching of anatomy, physiology and hygiene is based on the theory of nervous activity, propounded by Academician I.P. Pavlov. Basic concepts of physiology are established in the minds of the students. An idea of exchange of substances as the basic property of life, where assimilation and dissimilation are the two sides of one process, is shown. A physiological explanation on the harmony of the organism which depends on the action of all the systems of organs, is given. The leading role of the nervous system in the establishment of harmony in the organism and its relation to the external medium (stimulus) are emphasized. While teaching physiology, the special features of the higher nervous activity of man is taught, paying attention to the reflex character of nervous activity. Importance is given to the establishment of interrelations between the structure of organs and their functions. In doing so, always the correspondence of these relations, their temporary evolutionary character, in animal organism, are always emphasized. At the end of the course the topie 'origin of man' is studied.

Teaching of anatomy and physiology of man, prepares the students for labour by acquainting them with knowledge of physical labour for the correct development of human organism, and with the elements of physiology of labour, rules of hygiene and proper use of labour, in production. Besides, the students acquire the skill of giving first aid, conducting and organising useful gymnastics. A course in biology is taught as an exclusive division of the school course of biology in the class IX (78 hours). The aim of this course is to deepen the understanding of the laws of life, development of organisms and evolutionary developments of the living world as a whole. A large part of the course (31 hours) is allotted for a deep study of general

properties of organisms. The cellular structure of multicellular organisms, the basic functions of their cells: nourishment, breathing, stimulation, growth and reproduction, the basic groups of unicellular organisms, noncellular organisms—the virus. The exchange of substances as the fundamental property of organism and the differences and similarities in the exchange of substances in animals and plants: relation between photosynthesis and refraction? Role of green plants in space experiments, etc., are studied in detail. The multiplication, individual development of organs and their relation with the conditions of life are studied. Special attention is paid to the question of conservation of nature.

The next large division of the course is devoted to the evolutionary development of the organic world and knowledge of its laws. Here, the students are acquainted with the origin of life on earth, the laws of development of the organic world and the basic propositions in the theory of Darwin. Special attention is paid to Michurin's theory on the transformation of the nature of living organisms. The question on the origin of man is examined at a level higher than in class VIII. The course is concluded with generalization on the uses and achievements of the biological science in the various spheres of production: in agriculture, medicine, various fields of industry and in the problem of conquering space.

The teaching of biology in the middle school is especially successful where the teacher uses various methods and measures which encourage active participation of the students. This is achieved by conducting laboratory experiments using naturally occurring materials, setting up of experiments and observations on plants and animals, by excursions into nature, to agricultural farms, and by working on plots allotted for experimentation in the school. As has already been shown, the teaching of biology in all its stages, is closely related to practical labour. The latter helps the students to use knowledge obtained in the school in practice and develops a love for labour. Relating the study of biology with labour activities of the students helps in retaining more fully the knowledge of this subject attained by them.

The system of study combined with work, helps the students in acquiring essential habits of work, teaches them to prepare the soil for any garden or field culture, planting and raising plants, observe their growth and development, register the observations and maintain a dairy and so on. The students must learn to work in the orchards or in a forest nursery, grow vegetables, destroy harmful insects, look after animals (calves, young pigs, rabbits and birds).

Of late, greater and greater importance is being given to the introduction of experiment for sharpening the productive skill of school students. A separate field of specialization called "experimentation' has been created. It is closely related to the problems of agriculture. The experiments of the students are divided into two groups. Experiments of perceptive nature which help in the deeper understanding of the various divisions of the course of biology, come under the first group. They are done on small pieces of land (1 m^2, 5 m^2, 10 m^2)

in hot-houses or in the classes. This method of teaching has been applied successfully since long, by the teachers. The scientific development of methods on controlling growth and development of plants and animals come under the second group. The topics for this experimentation is determined by the requirements of the agricultural economy of the region in which the school is situated. The results of experiments done on a large territory can be used by the local agricultural organisations. Experiments of this type must be done on plots not smaller than 50 m^2 with triple replication and control so as to be sure of the results. Topics of such scientific experiments are application, of trace elements, biostimulators of growth and herbicides in field-crop growing, testing of maize strains and other cultures; bettering the seed stock; study of the influence of trace elements and antibiotics on the growth of calves, young pigs, chicks, ducklings and others.

For doing experiments in field work in biology and agriculture each village and several urban schools also, have student experimental plots of land. The area of these, is up to 2 hectares in rural eight-year schools and up to 0.5 and sometimes up to 1.0 hectares in urban schools. On such school plots experiments are conducted successfully. But the dimensions of the plots limit the possibility of setting up of scientific experiments. However, in many eight-year-schools interesting and essential research is done even on small plots.

In the middle schools along with training in agricultural production training is also given in farming of plots several hectares in area, (depending on the location of the school) which are equipped with modern agricultural machines. Here, there are all facilities for developing experimental work among the students. Besides, in a number of schools training in labour and production is given according to the brigade method. Students from classes VII to XI often form one which is split into teams. Each brigade as well as team is headed by an elected student. The school brigade works on fields, collective farms and state farms, applying advanced agricultural techniques. A considerable part of the land (up to 400 hectares and more) is reserved for the school brigade. The students themselves do all the agricultural work on these plots. The student brigades have their field camps with the canteen, library and agrobiological laboratory. The work of the brigade is done according to a plan of production chosen earlier. This plan is approved in the meeting of the brigade and is in accordance with the rules of the collective and state farms, that is, the brigade of school students is actually included as a part of the collective farm.

Students of VII-VIII classes work for 4 hours and IX-XI classes for 6 hours in a day. The work of children is combined with rest, entertainment and favourite sports.

In the student brigades experimentation is on a grand scale. Part of the plots tended by the students come under experimental farming. The results obtained can be verified on larger territories by the students themselves.

In December 1962, results of All Russian competition for the best experimental work in schools, were given out.

It was found that, in several regions and autonomic republics, all the eight-year and middle schools were included in it. In the territory of Krasnodarsk, there were 654 such schools, in the Belgrade region 539, in Kaluzhsk—516, in Ulyanovsk—411, in Volgogradsk—438, Mordovsk ASSR—304 and in Stavropolk territory 320 brigades and 139 societies of young experimentators had been set-up. The schools which attained best results were awarded prizes.

The topics for experimental work are increasing year by year. For example, in the Archangel region research on the advancement of maize in the North is being done. In the black earth regions work is being done on the study of the influence of the area of cultivation on the harvest field of sugar beet, by using bacterial fertilizers; the influence of additional pollination on the harvest of buckwheat and so on. Advanced schools are combined with farms of collective and state farms demonstrating experiments and with experimental stations and agricultural institutes.

Experimental work has a great influence in the formulation of the personality of the students. A deep interest in the process of conducting experiments, creative joy on attaining positive results, collective friendly team, work, competition between the teams all these create love for agriculture in the students. The students of the middle school have a pride of choice of profession after productive training in professions such as plant growing, stock breeding, assistant in agro-laboratories and so on. Many students who finish middle school, after working in student brigades, remain and continue to work on the place where they were trained in production.

What Should Be Learnt in a Secondary School Physics Course?

K. Hecht

THE plans to modernize German secondary school education that have recently been put forward from various sides have one curious characteristic in common. However much their conceptions of how to adapt school education to modern requirements may differ in other respects, they all suggest giving less consideration to the natural science subjects than has been the practice in German secondary school education during the past few decades. The more radical plan of this type is the draft agreement of the Ministers of Culture of September, 1960. It purports to provide for an intensification of teaching by reducing the number of compulsory subjects and by coordinating the subject-matter to be presented, and thus to educate the students in a spirit of mental independence and responsibility. This idea is catching and meets with due recognition in various quarters. The means suggested for the attainment of this object have, however, roused much opposition on the part of scientists, businessmen, school teachers and parents. For the above aims of the draft agreement are, *inter alia*, to be realized by abolishing completely the instruction in the natural sciences, which has hitherto been compulsory in all types of schools; in the upper forms of secondary schools specializing in the arts (*sprachliche Gymnasien*) and by abolishing biology and chemistry in the upper forms of secondary schools where stress is laid on mathematics and science (*Mathematisch-Naturwissenschaftliche Gymnasien*). This is to be replaced by the introduction of optional subjects, the students being free to choose between an arts or a science subject. In addition to that, the agreement moreover provides that one of the so-called basic compulsory subjects (*Kernpflichtfach*), e g. mathematics in the case of an arts school, can be terminated in advance.

The objections against this plan have as a nucleus the idea that it would mean abandoning the principle of providing a general education in the upper forms of German secondary schools, in favour of a premature specialization. This general education within the meaning a 'studium generale' is considered to constitute the chief educational task in the upper forms of secondary schools and is thus looked upon as an essential qualification for university entry. Many objections are directed against the fact that the draft agreement would kill the science subjects in an untimely fashion.

The natural sciences have had far-reaching effects on the thoughts and actions of mankind. No one can fail to be aware of the radical changes which make our scientific and technical age so different from the past not only in its outward appearance, but also in its spirit.

From a lecture by K Hecht given on June, 21, 1961, in Frankfort Main.

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Yet the draft agreement sees no harm in the fact that during their last, decisive years of schooling the secondary school students are no longer obliged to come to grips with the science that have contributed most decisively towards this change of structure of the present age. Obviously, then, the importance of natural science teaching for the education of independently-minded, responsible young people who will have to prove themselves in a future evolving with yet greater progress in science and technology, has in no way been properly appreciated. It seems necessary therefore for me to advocate once again the importance of science teaching in the upper forms of secondary schools in an all-round general education.

In what follows I shall restrict myself to a single science subject, namely, physics, where I am most at home. However, I should like to point out that chemistry and, above all, biology, have other, important contributions to make in secondary school teaching, in view of the characteristics of both their methods of enquiry and their results, which will now almost certainly fail to come into effect. Physics cannot be considered as a substitute for these disciplines. On the contrary, what must be provided is a co-ordinated education in all three subjects, otherwise one cannot adequately appreciate the methods of thinking of present-day science and the spirit of the age that bears its stamp.

I shall try to form an estimate of the place of physics in a 'studium generale' by putting the following questions: Can the pursuit of this science in class convey an adequate knowledge of its basic foundations? Can it develop the capacity for clear and independent thinking? And can it contribute towards the formation of a personality able and willing to co-operate in the tasks of the future?

In this the object of physical enquiry, the method of enquiry peculiar to it, and its practical application by the individual as well as by the community prove unexpectedly fruitful, even within the scope of school education. In physics education the students learn to derive the most important concepts, fundamental laws and relations of physics by rigorous, logical conclusions drawn from observations made in the course of careful experimental work. The examination of the method of enquiry peculiar to physics, which combines abstract mental processes and experimental, empirical experience, and of its applicability and limitations, shows what possibilities physics teaching holds in store for the education of the mind. This I shall explain at greater length in the light of the examples described in what follows. Yet I would like to stress two further points of view here, because they give a special value to physics teaching, the finding of completely novel and unpredictable natural phenomena, and the sense of wonder at the majesty of nature this instils in the thinking mind.

Thus it is not at all a question of just communicating 'subject-matter' or 'facts' which the students can pick out for themselves in passing, more or less as a hobby, as one can sometimes read in educational literature. By this method no one would be able to penetrate into the spirit of the sciences and into the structure of our scientific and technical age. Science teaching has greater tasks. What matters is the experimental experience and its mental digestion; only the combination of these two basic elements

leads to an appreciation of the thrill inherent in the discovery and exploration of a new world that would otherwise remain hidden forever from the human mind. One would not learn to understand our intellectual contribution at our times 'that thought must abdicate where it runs counter to the creative order'[1].

These points of view should always remain before our eyes when we try to assess the role of physics teaching in general education. To begin with, let us once more call to mind the aims and the scope of secondary school physics teaching. Is it not true that the undervaluation of the natural sciences frequently springs from the erroneous view that the education in these subjects is introductory course work for future scientists rather than a contribution to general knowledge? This overlooks the fact that a physics course has something to offer to all students. Of course most of them will not choose a scientific and technical career; but their only opportunity for concerning themselves with the natural sciences is at school, especially in the upper classes. Later on, when they practise their professions, they will be faced increasingly with problems which can neither be understood nor solved without some knowledge of the natural sciences. If the coming generation is robbed of its only opportunity for an intimate acquaintance with the natural sciences, then ignorance, wrong assessment and thoughtless application of the material and intellectual achievements of these disciplines can cause grave damage. That is why the physics teacher should always warn the students of the responsibility that goes hand in hand with the technical and scientific evolution and its applications. It is not enough to leave the students to choose, if any, with what science subjects they wish to become acquainted. In actual school practice, rather curious and generally irrelevant reasons for selecting or rejecting such subjects have been brought about. On the other hand, it will not do to simplify the presentation of subject-matter and method by a restriction to a few typical examples, and by the sacrifice of more recent fields of physics, under the pretext of making things easier for overworked students

In order to appreciate the most important foundations, to develop independent thinking, and to gain an impression of the method of enquiry peculiar to physics it is necessary, on the contrary, to treat the phenomena selected for the course according to the principles of thorough teaching[2]. What this means will be explained by the following examples:

1. In mechanics what is to be aimed at is a consistent presentation comprising the kinematic and dynamic phenomena including rotary motion, the level of instruction being such that the most important fundamental quantities and fundamental laws up to the laws of planetary motion can be understood. In these fields the student has everyday experiences which must be collected, sorted, and critically examined. Thus if one wants to derive simple functional relations between space and time, that are common to widely differing types of

[1]From the memorandum of the Faculty of Science of the Munich University on the Saarbrucken draft agreement of the Ministers of Culture on the Reorganization of Teaching in the top forms of secondary schools

[2]H.A. Ristau, Überwindung der Stofffülle in Physikunterricht (How to master an excess of subject-matter in physics teaching), MNU 13, 468, (1960/61)

motion, then the complex conditions prevailing in the case of an individual process—for example, of a flying bird, a driving motor-car, a sailing boat—must be analyzed to find common characteristics. One must seek to free the process in question from side issues. In this analysis of experience the aim is to study a process that is easy to apprehend, and the method of carrying out such a process.

In this way one becomes acquainted with the first conscious effort to extend the range of everyday experience, by conceiving the idea and the plan to perform an experiment. This requires inventive, constructive thinking and forms a part of the preparation of the experiments in class. It should be encouraged even if the experimental arrangement requires some technical and other expenditure.

These fundamental elements of the method of physical enquiry are typical of the methods of our age. It is true that even the ancients had occupied themselves with the treatment of kinematics. But one was content with traditional experience and tried to explain the phenomena from general speculations. Thus Aristotle's physics was dominated by the search for the 'prime mover'. Not until the time of Galileo did it occur to anyone to seek a simple relation between position and time in movement and to devise experiments that might provide information on this point. Following this example we have adopted the method of sifting the available experience, suggesting possible casual relationships, forming a hypothesis and deciding to test it. For this purpose it is necessary to think out, to assemble, and to operate suitable experimental apparatus.

The experiment then shows whether the process in which we are interested can be observed free from side effects. This is not possible for example in the case of a ball that one rolls across a table to study rectilinear motion. It is retarded by friction and deviated from its course by inequalities of the surface. Only the

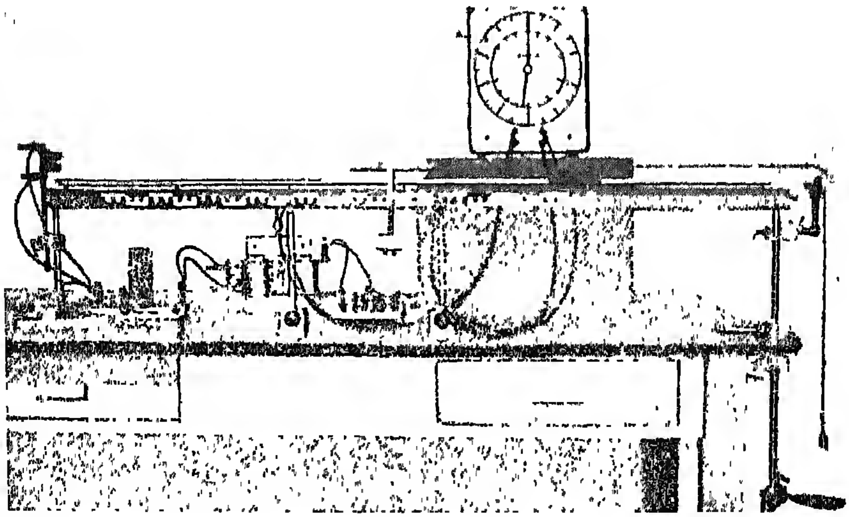


Fig. 1

smooth track and its slight inclination to compensate friction, as used in Fletcher's trolley (Fig. 1), enables the study of the rectilinear motion of a trolley by recording position and time.

Even the qualitative observation of this process is instructive, new experiments suggest themselves which can be represented by statements like 'the faster the trolley goes, the shorter the time in which it covers a given distance'. In order to derive statements which are universally true one must free oneself from the single example. This is taken into account by further steps in the logical method used in physics, such as the definition of fundamental quantities and of the units in which these are to be measured, and by their use in the apparatus prepared. The measurement may supply simple relations between the measured quantities, after all, that is what had been expected and had prompted the experiment. Thus with *Fletcher's* trolley one can find that the trolley, once started, will cover equal distances in equal periods of time. The relation between distance and time leads to the ideas of velocity and constant and accelerated motion. By repeating the measurements sufficiently often one gains the confidence to generalize the relations so found. The functional relations between the observed quantities and the laws of physics are derived from the measurements by inductive reasoning. Small deviations of individual observations come to be recognized as inadequacies of the measuring procedure, or of the measuring instruments. The law itself supplies the idealized form of the relation sought, even if there is always a limit to the degree of accuracy with which the phenomenon itself can be observed in one or in many determinations. This scientific method employed in physics can only be explained and treated slowly in class, applying the principles of thorough teaching. The relations of mechanics are by themselves difficult enough to grasp and would seem incomprehensible to a student if he were burdened at too early a stage with an analysis of the underlying processes of thought and perception. The reason why I have tried to represent them in a coherent manner along with the very first example was that they are applied accordingly in the same manner in all fields of physics.

2. This is true, for example, in the case of dynamics Thus if one passes on from the immediate experience of muscular strain, or from the readily conceived forces of inertia, to a treatment of the fundamental law of dynamics, the two new quantities force and mass are introduced in an almost identical manner. From an analysis of the available evidence one suspects a relationship between the force and the mass and motion of a body. Hence the experimental arrangement must permit the observation and measurement of a rectilinear, frictionless motion of a body of variable mass, on which a variable force acts in the direction of the motion. This can be achieved using *Fletscher's* trolley with guide pulley and the weights of metal blocks as driving forces. (To leave out this observation, because from its result a definition of force will be derived later on, would be contrary to the spirit of the method of physical enquiry.) This measurement leads to the fundamental law of dynamics. force equals mass times acceleration, with an accuracy sufficient for first introducing this fundamental law. When the quanti-

ties involved have been clarified, the experiment can be repeated later on if necessary, and any errors inherent in the arrangement can be found by careful experimenting. They are due to a neglecting in the first analysis of the experimental results the inertia forces due to the acceleration of the wheels and driving blocks. These must be considered in addition to the forces required to accelerate the trolley (*d'Alembert's* principle).

3. The results of the experiments are expressed in units and numbers; hence the relations between physical quantities following from the observations are expressed in the symbolic language of mathematics. In doing so one is surprised to find that the physical observations can be represented by mathematical functions. On account of this fact mathematics is a suitable tool for deriving deductive conclusions from laws of physics. These in turn can then prompt an experimental investigation for their further confirmation and open up the wide field of technical applications.

An example of such deductions and experimental investigations is provided by the processes observed with *Maxwell's* wheel (Fig. 2). Here the fundamental law of dynamics is applied to rotary motion and to the retarded and accelerated upwards and downwards motion of the wheel on the balance.

If observations have not supplied simple relations, but have only given rise to further speculations, then one seeks to make deductions from these as well and to test them by experiment. Later on we shall find that even quite unexpected phenomena can be discovered in this manner.

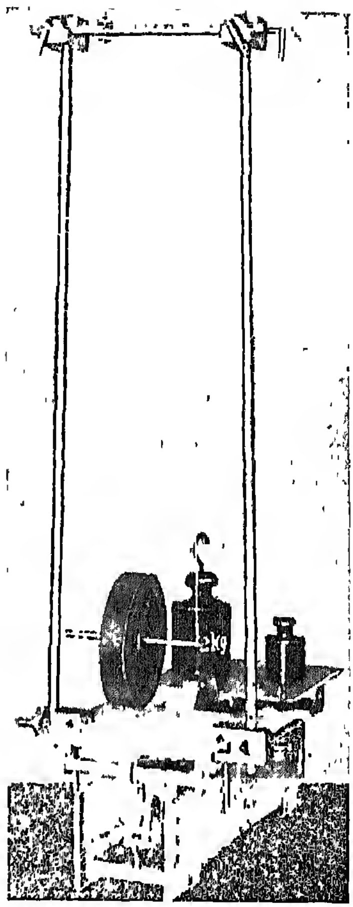


Fig. 2

4 The methods of physics, of which I have given some examples from mechanics, are applied in other fields too, e.g., in electricity. The observation of the force acting on a charged body in an electric field can still be linked with everyday experiences of the students: the play with small bits of paper or cork in the field of rubbed insulators. But then the physical notions and quantities must be clarified in the course of further experiments. Their mutual relations can be observed using an arrangement in a

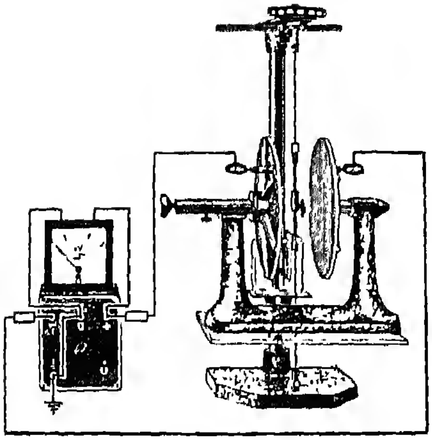


Fig 3

homogeneous electric field, see Fig. 3. The force exerted by the electric field in the parallel plate capacitor upon a small, charged metal plate arranged at its centre is measured with a torsion balance. These observations supply the important fundamental law: force equals charge times intensity of the electric field.

5. In this experiment we make the same observations as in the case of the fundamental law of dynamics; the exclusion of all side effects is not easy. In the introductory experiments it is, of course, possible to select conditions so that the fundamental law can be derived from the observations with an adequate degree of accuracy As the students get more familiar with the subject-matter, the observations can be analyzed with greater care and the additional forces due to electrostatic induction in the metal parts used (electrostatic image force) can be treated at greater length to deepen the students' understanding of these processes.

6. Let me now turn to the observation of the forces between current-carrying conductors and magnets. The systematic presentation that begins with introductory experiments and leads to the fundamental relations of electromagnetism has special importance because it leads to an understanding of the electric machines so widely used in engineering. This seems worthy of mention in this context not only because it is one of the examples which show most clearly how a technology based on laws of physics has changed in a revolutionary manner the working and living conditions of mankind, but also because in these technical applications the validity of the physical foundations was unquestionably verified.

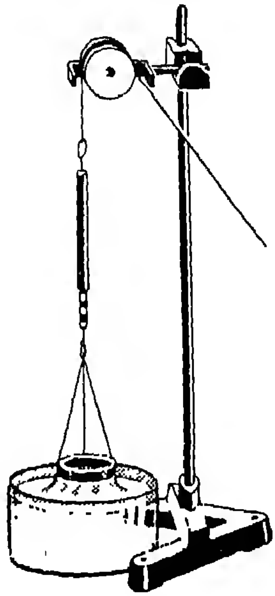


Fig 4

7. As further examples of physical advances I now take some from the field of molecular and atomic physics. The properties of materials are frequently treated in class; e.g., the change of length of a wire extended by the application of increasing stress, the change of resistivity of an electric conductor as its temperature is varied, or the observation of the surface tension of a liquid (Fig. 4). Here too the

method of enquiry adopted follows the same pattern characterized by the joint application of theory, experiment and interpretation: the analysis of everyday observations leads to conjectures concerning possible relationships which prompt the invention of an experiment; this is then performed and the information supplied by it is recorded and evaluated.

The law derived therefrom by inductive reasoning then summarises a newly won item of physical knowledge in concise statement.

8. The observation of surface tension effects shows that liquids will contract to pellets on surfaces they do not wet. If several such pellets are brought near one another, they tend to combine to reduce their overall surface area. This can be shown by an impressive experiment[3] A fine capillary tube made of glass is used to bring many small mercury droplets into a watch glass containing some acidulated water. On account of surface tension the total surface area of the mercury tends to be a minimum. As the droplets come into contact with one another, individual droplets will combine to form one large drop of mercury. This process is easy to observe, especially in projection. The combination of two mercury droplets is a random event; but when the experiment is repeated several times under identical conditions, it will be found that the individual experiments resemble one another rather closely with respect to their course in time. The more observations are made, the more accurately can the time be stated after which the number of droplets will have reduced to half, and the greater is the degree of confidence with which the standard deviation of this half-life is known.

9. This experiment is a simple and illustrative example of a random process. For in physics, the method of enquiry is applied even to such processes and leads to remarkably accurate predictions concerning their course. The greater the number of determinations made, and the greater the number of individual particles concerned in them, the greater the accuracy with which statements about the general behaviour can be made, even though it is impossible to predict the behaviour of any one particle.

The statistical representation of many properties of matter has come to play an important part in physics, especially since there is conclusive experimental evidence for the atomic and molecular structure of matter. The power of this statistical method was first evinced by the kinetic theory of gases. The laws representing the interdependence of pressure, volume and temperature of a gas can be derived by it with a surprising degree of accuracy, considering the extremely large number of gas molecules concerned in the experiments.

10. Indeed, the study of the behaviour of a very large number of similar particles furnishes information on the property of an individual particle, since the observation of a single particle is usually impossible. This I should like to explain by the example of the gas-focused cathode ray tube (Fig. 5). Now this tube can be used to give an impressive demonstration of the deviation of an electric current by a magnetic field. The electric current here consists of electrons concentrated into a narrow, luminous beam by gas-

3. *Pohl*, Mechanik, 13th edn, para. 78. p. 124, and *Bergmann-Schaefer*, 5th edn., para. 68, p. 818.

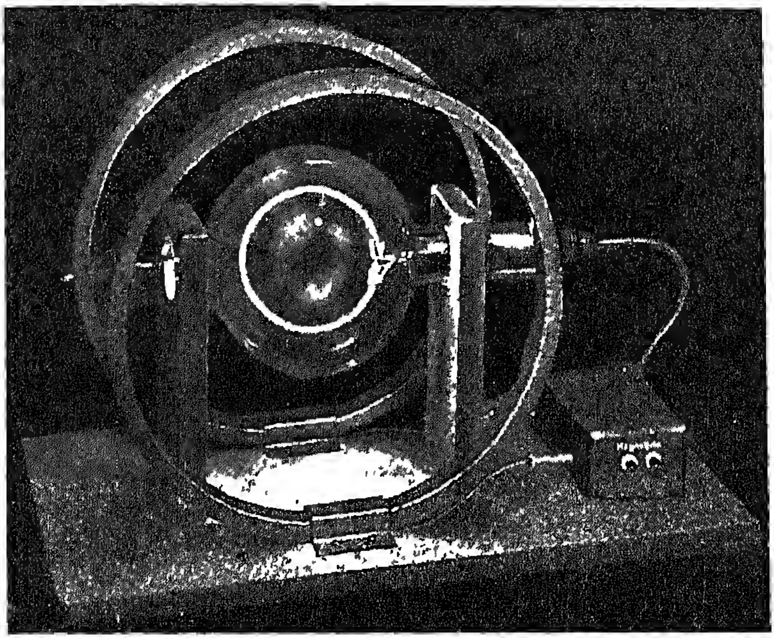


Fig. 5

focusing. On applying the experimental results of the dynamics of moved particles, and of electromagnetism, to the observations made on the gas-focused cathode-ray, one finds the charge-to-mass ratio called the specific electronic charge as a property of the single electron. It is completely impossible to measure the specific electronic charge of one isolated electron. But the specific electronic charge can be measured for the large number of electrons that make up the gas-focused electron stream in the tube. This experiment also shows that individual particles of like nature cannot be distinguished from one another

11 Our knowledge of the molecules, the atoms, and the other elementary particles is also due to a clever and consequential application of the method of physical investigation. School physics includes a remarkably large series of experiments from atomic and nuclear physics which provide experimental evidence for the existence and some of the properties of such elementary particles. The size of an oil patch on water can supply information on the dimensions of oil molecules; the Brownian movement makes the thermal motion of molecules in liquids and gases intelligible; the field emission electron microscope renders the effects of individual barium atoms and their thermal motion visible, in Wilson's cloud chamber one can observe the tracks of the elementary particles emitted in radioactive decay; nuclear plates (Fig. 6) show the tracks of atomic events that are caused by cosmic radiation. These are only some of the available teaching experiments of this kind. They not only supply the experimental evidence for the atomic structure of matter that had been suspected for thousands of years, but give also

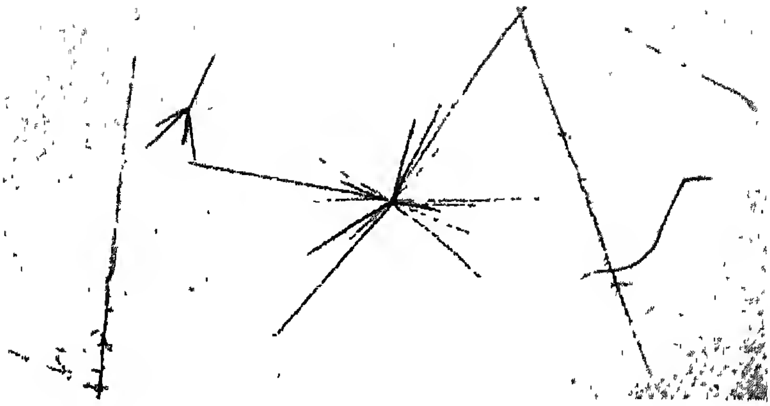


Fig 6

glimpses of the unfamiliar and hardly imaginable world of the microcosm and therefore a knowledge of quite novel and unimaginable natural phenomena. To come to know them and to learn what far reaching consequences spring from them for present-day-knowledge, for the course of future research, and for possible applications is part of the wonderful opportunities offered by physics teaching. The wonders of nature which present themselves here have led the most exact of the natural sciences, physics, to momentous conclusions. To quote a few examples:

12. The discoveries made by W.C. Rontgen, prompted H. Becqerel to concern himself, in the spring of 1896, with the fluorescence of uranium salts, as he thought that the fluorescence of these salts had something to do with the origin of X-rays. This assumption he was forced to give up; but instead, he discovered uranium radiation, the first known case of radioactivity, in the course of his suitably devised experiments within a few months. This discovery is only 66 years old. But how revolutionary are the results of research and the technical applications of the new field of nuclear physics it has initiated! Once more nature proved to be far richer than could have been known without a conscious application of the methods of physics.

13. Students taking a physics course can experience anew the discovery of the radioactive phenomena when watching or performing experiments with simple ionization chambers, counting arrangements, cloud chambers and like. The experiments leave behind an unforgettable impression; they demonstrate why the course of planned observation of nature adopted by the natural sciences alone is able to reveal this world of phenomena to us.

14. I have mentioned the experiments with the gas-focused cathode ray tube from which conclusions can be drawn concerning the properties of individual electrons (velocity and specific electronic charge). This suggests a similar experiment on the deviation of β-rays by a magnetic field (Fig. 7) in order to learn more about the properties of β-particles than can be derived from absorption

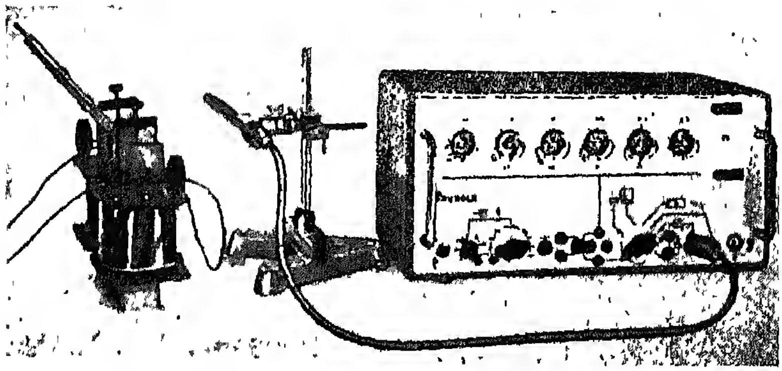


Fig. 7

measurements alone. The experiment indeed gives remarkable results the β-particles are deviated by the magnetic field; they have a negative charge and can, therefore, be indentified with electrons Furthermore upon computing the velocity of the β-particles from the measured values similarly as in the case of the gas-focused cathode ray tube, one obtains the surprising result that their velocity must be greater than that of light. But this is in contradiction to all other findings of physics, which exclude the possibility of moving particles ever exceeding the velocity of light. If this is considered in the evaluation, one is forced by the results of the experiments to conclude that the mass of the extremely fast β-particles is greater than that of the relatively slow electrons in the gas-focused cathode ray tube. Hence the quantitative evaluation of this experiment leads to an understanding of the dependence of mass on velocity, as a result of special theory of relativity. From the fact that the value of the mass of a very fast body increases as its velocity approaches that of light one can moreover infer the equivalence of mass and energy. That mass can be transformed into energy and, conversely, energy can be transformed into mass, is one of the most fruitful results of modern physics. It cannot be grasped using the conceptions of classical physics Hence we must also accept such new results as are unfamiliar to our minds in order to describe the observed natural phenomena consistently.

15. The determination of the velocity of light (Fig 8) is one of the basic experiments in education In 1904 an interference experiment performed by A.A. Michelson had shown that on the earth which moves round the sun with a velocity of 30 km/s, the velocity of light has exactly the same value in every direction. This experiment cannot be performed in class; but its result is extremely important It can be used to discuss with the students the observability of simultaneous events in systems that are moving relatively to one another. The experimentally founded constancy of the velocity of light, which cannot be exceeded, neither by fast-moving particles nor by communication signals, can then help them to see that statements of time cannot be made independently of position. The old notions of an absolute space and of an absolute time independent from it are,

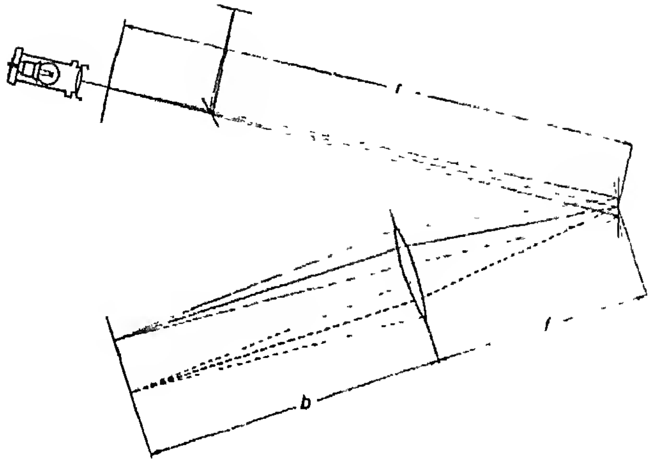
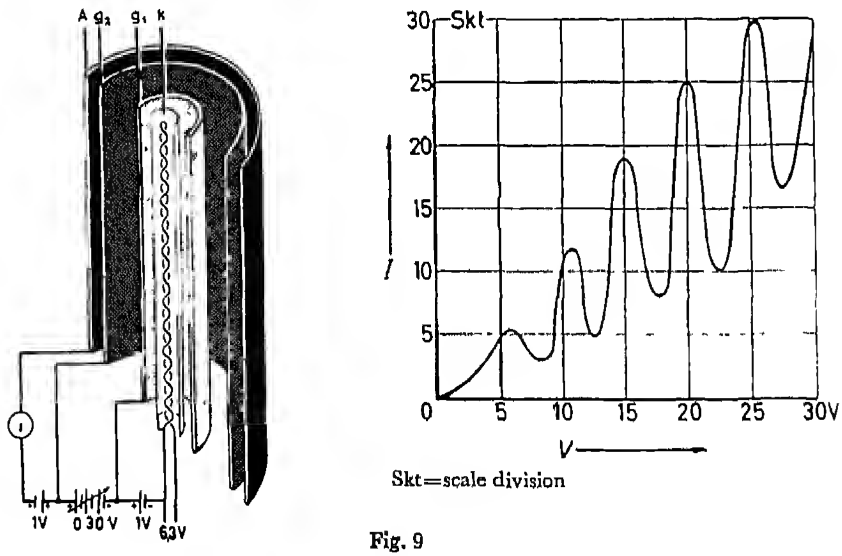


Fig. 8

therefore, habits of thinking which cannot be made to agree with the results of research. Here, too, thought must resign because the order of creation is different from what we should have expected before obtaining evidence to the contrary.

16. Similar conclusions force themselves upon the mind in other fields of modern physics, such as quantum physics Naturally a school physics course can only present a very few simple examples on this field; but these suffice to bring out the remarkable new features of this entirely new world. The experimental basis is provided by the well-known Franck-Hertz experiment (Fig 9). The scanning of mercury atoms with impinging electrons of continuously variable energy supplies the result that mercury atoms will only be excited if the energy transferred in the



Skt=scale division

Fig. 9

collision has certain values. In the atomic region, energy too, has a granular structure. Only discrete quantities of energy, the quanta (photons), can be received or released to bring about changes in the structure of the atom. The quantum theory developed by M. Planck explains these processes, as well as those involved in the photoelectric effect and in the absorption and emission of light in gases and vapours. The 'Balmer' series of the hydrogen atom, a sequence of spectral lines, for which the Basel secondary school teacher was the first to be able to state a series formulae, is generally cited as an important example of this type. The photoelectric effect, spectral lines and the Franck-Hertz-experiment represent the basic phenomena of quantum physics in a school physics course. This new field of physics has also considerably changed and expanded the notions of classical physics by providing new items of knowledge. For a long time science had been striving in vain to get behind the secrets of the manifold spectral phenomena. Here the discovery of the quantization of energy provided a key and revealed once more novel proprties of nature nobody had foreseen.

17. Recent physics accounts for quite a number of discoveries of this kind which necessitated the giving-up of traditional views, and forced the workers to accept the new facts which could never have been derived by mere speculative thinking. Many of these discoveries cannot yet be treated experimentally with the simple means available in a schol physics course, so that I shall have to omit them here, although for example the statement about the complementary nature of waves and corpuscles would be another important example. Instead, I should like to point out the tracks due to the simultaneous production of an electron and a position that are found in most nuclear plates These are formed when an incident high-energy photon (gamma ray photon, $h\nu > 1.02$ MeV) is transformed into an electron-positron pair in the field of an atomic nucleus. The materialization of energy which is here observed is a convincing proof of the equivalence of energy and mass which follows from Einstein's relativity theory and to which I have already alluded when mentioning the deflection of β-rays. I think one should not withhold from the students the deep impression they can receive when examining a nuclear plate and especially when finding the tracks of an electron-positron pair on it.

18. Now let me show the limits of observation using an example from classical physics, the resolving power of a microscope. The relevant theory is due to Abbe; a pertinent experiment can be performed in class (Fig. 10). The diffraction of light by the structure of the object determines the quality of the image; the wave-length determines the limits of the resolving power of a micro-

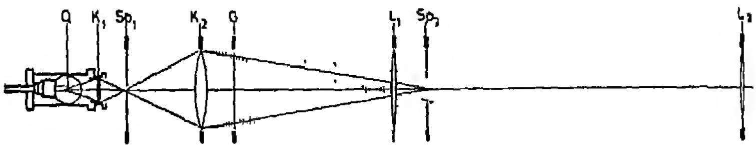


Fig. 10

scope. For the same angle of aperture of the cone of light, the distance between two points in the object that can just be resolved depends on the wavelength of the light, the smaller the wavelength, i.e., the larger the frequency of the light used the smaller the distance. Therefore, for the same aperture angle, the distance that can just be resolved, and the frequency of the light used, are complementary quantities. If the frequency of the light used to produce the image is such that it remains within the visible part of the spectrum, then the structure details of the object that can be resolved will be of the order of magnitude of one wavelength. Hence the resolving power is not only a problem of measuring technique, but also is limited by basic principles of physics.

The limits of observability or the inherent indeterminancy of a physical measurement independent of the unavoidable errors of reading are of special importance in microphysics. This is expressed in the indeterminancy principle stated by Heisenberg. According to it, the coordinates and the momentum of a particle, or the energy and the time of an event, cannot be measured to an arbitrary degree of accuracy simultaneously. The more certainly the one quantity is determined, the more uncertain is the other.

Such reflections on basic limitations of observability are important in other fields of physics too, e.g., in the new information theory. It is part of the method of enquiry adopted in physics to find out the limits of its applicability. If it is in keeping with the nature of physical enquiry that the enquiring mind becomes conscious of the limits of its power of enquiry and can state them precisely, then it is misleading to call this the limitations of physics. These are determined by its field of application consisting of the study of the phenomena of the inanimate nature.

19. The influence that physics exerts on the life of the individual and of the community through the application of its results is also within the purview of physics education. Here I am not thinking so much of the technical applications in their machines and apparatus designed for these purposes, as of their influence on the shaping of human life. In the first place, the technical applications of physics bring to our minds daily how much and how confidently we always and everywhere rely on the validity of the physical laws on which they are based. Once such applications are in use, they soon come to be so generally accepted, that everyone makes a claim to their use. Correspondingly, the sociological importance of these applications in this present technical and industrial age is enormous. Whereas the balance, the oldest physical measuring instrument, has been used in human industry and commerce for thousands of years, it is only in these days that the production and distribution of energy, the transport and communication services, the automatic control, the industrial production of almost every kind of merchandise, which render the technical application of the results of physical research practically indispensable. It is not, therefore, at all surprising that among the students attending physics classes there can be found an increasing tendency to ask for an explanation of technical innovations. Even though a school physics course is no place to discuss the constructional detail of engineering equipment, such questions put by students

should always be taken up readily and related to their physical foundations

20 As an example of a physical process underlying many technical applications I might mention the generation of undamped electrical oscillations with thermionic valves according to the principle of negative feedback (Fig 11). Its applications in telecommunications, broadcasting and television are obvious

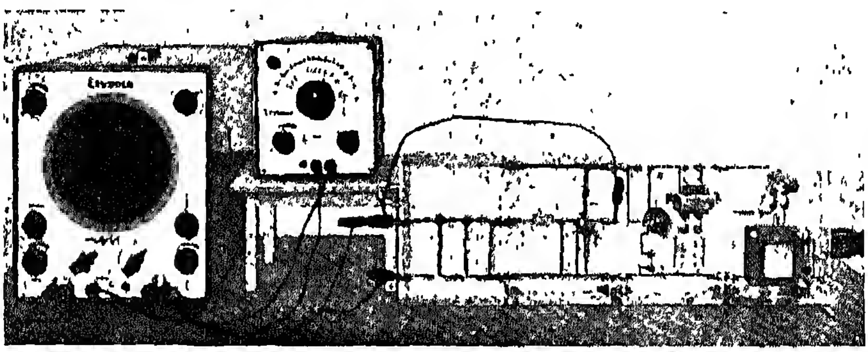


Fig 11

Occasionally it is possible to help a radio-amateur boy, who may be quite skilful at his hobby, but has probably not given much thought to the underlying foundations (having only superficially acquired the jargon) to come to an understanding of the physical principles he is using.

The examples of school experiments I have quoted to illustrate the method of enquiry of the natural sciences and the results it provides have been drawn from several fields of physics. Of course comprehensive physics teaching cannot restrict itself to such a small and arbitrary selection of experiments as were used to indicate what can be learned in a school physics course. The principles governing the thorough teaching of physics have been repeatedly cited[4] and have been generally accepted by physics masters. One endeavours to select such fields of physics where careful experimental work enables the observation of basic phenomena, and the laws of physics and the ways in which they are connected can be derived from the experiments. If this is done consistently with the selected subject-matter, then the students will gain a knowledge of the basic foundations of physics and an insight into its effects on the thoughts and actions of modern times

4. *H A. Ristau,* Genugt exemplarisches Lehren? (Does teaching by examples suffice?) Schriften des Deutschen Vereins zur Forderung des mathematischen und naturwissenschaftlichen Unterrichts e. V No. 4, p. 10 et seq. Report on the meeting of the Physics editors from October, 7, to October, 10, 1959,

K. Hecht, Gedanken zur Stoffauswahl im Physikunterricht (On the right choice of subject-matter in physics teaching) MNU, **11**, 198, (1958-59)

E. Hunger, Die Bildungsfunktion des Physikunterrichts (The educational task of physics teaching), Vieweg Verlag 1959.

E. Buchwald, Die Bildung Physik (Education through physics) Vandenhoeck und Ruprecht, Göttingen 1956.

Über Bildungswerte der Naturwissenschaften (On the educational aspects of the natural sciences), Phys. Bl. **17**, 197, (1961).

and will be able to unfold and develop their intellectual powers thereon.

In doing so, the students will also understand that the experiment has an important place in the procedure that starts with an analysis of the available evidence and ends with the generalization of newly found results. This is where present-day physics differs from the purely speculative attempts of antiquity. The conscious step of increasing the range of experience by devising, performing and evaluating an experiment is needed to increase the volume of our knowledge of physics. An experiment may serve as a crucial test to eliminate one of two possible hypotheses, or it may not confirm either one of them, but bring to light something completely and unexpectedly new, as radioactivity in Becquerel's case. An experiment as an end in itself would be unthinkable. This would be mere manual dexterity and would in no way help to attain the object of physics teaching. The proper presentation of experiments, on the other hand, will bring out the typical structure of an experimental science

Apart from the actual performance of experiments, the objects of teaching include the description of the observations made. It is, of course, difficult, but very valuable as an exercise, to state simple relations concisely and accurately in simple words. In physics teaching this task acquires a special importance through the specialized language of physics where the meaning of terms is precisely defined by experimental experience. The student will tend, initially, to express his observations in the everyday language familiar to him. He has yet to learn how ambiguous and misleading this language can be and what advantages attach to the use of the technical terms of physics The way in which the experiments are described can then show whether the student has mentally digested the observations and conclusions, whether his concern with physics has enabled him to proceed to a clear and unswerving judgment, to objectivity and truthfulness In this process he will learn also to translate the physical quantities and the laws connecting them into the symbolic language of mathematics. This language proves even more helpful in the phrasing of strict and logical definitions, in the simplification of the theoretical representation and in the evaluation of the results of physical research that are to find technical applications.

I cannot over-emphasize the many links with the historical development, above all with the present, which physics education can bring to mind. One not only comes to know the great research workers and their discoveries, which have made basic contributions to the development of our culture, but also the change in the physical conception of the world that has taken place within the last few centuries. The perception of how experimental observation and theoretical investigation have cut more and more deeply into the traditional world of ideas is essential for an understanding of the present and future development. In most fields of physics the selected subject-matter is usually presented in the order of the historical development. As was shown by some of the examples mentioned earlier, one then has occasion to see what fundamental rethinking has to be done in order to come to terms again with the observed order of creation. Here one should not forget how the progressing scientific

development has simultaneously enriched the working life of humanity by its technical applications.

After this short presentation of the foundations of the method of physical enquiry I should like to point out in what essential respects a school-physics course, even in the upper forms, should differ in my view from a university course. In university science courses, the fields of knowledge concerned in lectures, practical work and seminars should be presented so exhaustively that every student can proceed to the limits of present-day knowledge by his own efforts Hence their object and method is characterized by systematic, consistent theories of present-day knowledge. But in school education what matters is not so much this presentation of self-consistent fields of knowledge; the object is not to provide a condensed university course, or to anticipate extensive knowledge Neither a complete course in analytical mechanics nor a complete quantum mechanics course would be in harmony with the spirit of physics education in school, they belong to the orbit of university teaching. In a secondary school, on the other hand, thorough teaching of the selected basic foundations should develop and exercise the mental faculties of the students. The best vehicle for this is provided by the various processes of thinking, by which the method of physical enquiry is distinguished, and by its results. Thus a school-physics course can enhance the volume of general knowledge of all students alike, so making them fitter for university education, no matter what professions they may later choose.

The technical language used by the physicist often fails to bring home the fact that the fruits of this thorough teaching have an intrinsic value for the formation of personality. The insight into the general laws by which the processes of nature are governed and to which man also is subject to a larger extent than he would generally like to admit are likely to instil humility and reverence The wonders of nature which reveal themselves to the students in their work even in the most exact of the natural sciences can safeguard them from vainglory. They may learn to appreciate the significance of the fact that in physics of all disciplines the thinking mind becomes conscious of the limits of his knowledge and understanding Not even here can he explain the processes of nature by mere reasoning, but must accept the natural order

I have now presented some points of view concerning the things that can be learnt in an advanced secondary school physics course. Are they really so insignificant that it might be left to the whim of a student whether or not he will attend this course in the last few years of his school life? On the other hand is it not true that the aims of thorough teaching in physics are of such grave importance for the student of today and the adult of tomorrow that they cannot be ignored all? Naturally such a general education in physics can and will attain its ends only in conjunction with corresponding courses in other subjects It is this coordination of all fileds of teaching which alone makes the desired general education possible. All courses must be selected and limited with similar ideals to those adopted in the case of physics, and the temptation to do university course work must be avoided. The notion of 'optional' subjects must not unilaterally limit the scope of a general education.

Young folks corner

Scientists You Should Know

THOMAS ALVA EDISON

(1847-1931)

MOST young school children, at least those who live in cities or towns, read in the light of an electric lamp But how many of these realize that their parents, when they were young, were not so fortunate. But illumination by an electric lamp is now taken very much for granted. The failure of power even for an hour at night causes vexation and annoyance.

Electricity as power was known from a very long time. From 1800 onwards attempts were made by inventors to use electricity to produce light. But all these trials failed.

In 1878 a young American inventor then 31, and already famous for his other inventions undertook to solve this problem. His reputation as a successful inventor was so great that everyone believed he would do it. At that time illumination of houses and streets was mostly by gas. The vested interests of the gas companies were afraid that they would go out of business. The story goes that some of these people controlling gas companies even attempted to sabotage the valiant trials of the young scientist.

Edison was born in Milan, Ohio on February 11, 1847. As a child he was intelligent but showed no signs of genius. But he asked many queer questions Edison found interest in books and he was always doing something with his hands. At first he would read anything he could find and later began to read books on science. Then he began to experiment. He set up a chemical laboratory in his house and began to earn money to buy chemicals and equipment. He tried growing vegetables in the kitchen garden and selling them. Later he was selling newspaper in a train. Soon he established his own printing machine in the luggage van of the train where he used to travel with his vegetables. He was selling nearly 400 copies of each issue of the paper, for which he was the owner, editor, printer and publisher This venture came to an abrupt end when by accident a container with phosphorus fell off its shelf and started a fire. The fire was put out, and so was Edison out of the train.

The next phase in Edison's life was his venture in telegraphy. When 15 years old, he rescued a boy from a rail track. The grateful father offered to teach him telegraphy. Later Edison got a job as telegraphist and became very efficient in speed. It was here that he made his first invention. The headquarters of the company required that all stations should

signal '6' in Morse every hour The small station where Edison worked was very punctual One night the headquarters called him back and got no reply On a checking it was found that the young man was asleep but had fixed an apparatus to the station clock that made it signal automatically. For this 'neglect' of work Edison was fired. Soon he got another job in Boston. He invented a 'Voting Recorder' in 1868 and it was his first patent But this was not liked by the politician who tested the machine. He did not want such a reliable machine to count votes.

Next year Edison migrated to New York and began to look for a job While waiting in an office building, the telegraph machine which reported the price of gold broke down. No one could fix it and the speculators were annoyed because their fortunes depended upon the machine. Edison repaired the machine in no time and was offered a job there. In a few months he set up as a professional inventor.

He invented a ticker which kept the stock brokers informed of the prices. He offered this for sale. The president of a firm bought it and asked the inventor to name a price. Edison was hesitating whether he should ask $5000, or accept $3000, but at the end left it to the businessman Imagine the surprise of the scientist when he was offered $40,000.

With this money Edison set up a large laboratory and worked on a number of new improvements in telegraph machines. He got married to a girl who was working in his laboratory.

In 1876 he moved to Menlo Park which later came to be called the 'invention factory'. So fast did the inventions come. He improved the telephone and invented the 'microphone'. He used carbon dust whose particles responded better to sound waves. It was here that he invented the 'phonograph'. When he and his mechanic were assembling the machine everyone including his assistant was sceptic about Edison's claim to make it talk He spoke a few words to a trumpet which was directed towards a cylinder of tin foil revolving under a needle. Then he set the needle at the beginning and turned the handle. Out came the first words a machine ever spoke The words were 'Mary had a little lamb, its fleece was white as snow—'. The world was astonished at the 'wizard' and his machines

After his success with the phonograph Edison turned to the problem of electric light. Scientists before Edison had attempted several times to invent an electric light but failed. Edison did hundreds of experiments in his search to find some suitable material which when placed in a vacuum tube, and electric current passed through it would glow producing light. He carbonized everything he could lay hands on before using it. Ultimately he succeeded with a scorched cotton thread, a fragile carbon filament.

On October 21, 1879 he set up a bulb with such a filament and it burned for 40 hours Electric light became a reality. On the New Year's Eve, following his discovery, the main street of Menlo Park was illuminated by electricity.

This was the climax of the great inventor's life. He continued to work for more than half a century and patented many more inventions which helped the motion picture and electronics industries.

One of these was a mechanism by which electricity from a filament passed on to a metal plate inside an incandescent lamp globe. This has become known as Edison effect. At that time its importance was not realized, but it made possible the radio tube and all the electronic marvels of today.

He ceaselessly worked in his laboratory till he died on October 18, 1931.

During his career Edison patented 1099 inventions. Inventions require hard work and hard thinking. According to Edison genius was one per cent inspiration and 99 per cent perspiration.

S. DORAISWAMI

Test Your Knowledge

What can a laser do?

Some day a ray of light, a laser beam could be used to make brick buildings stand without mortar. It would be used to form a single solid wall.

The laser, a narrow ray of light several thousand times brighter than the sun, can weld many ceramic materials, considered non-fusible. The new laser method of bonding would be practical in erecting buildings of brick or stone if time is short, as in military installations. Locally available materials could be used. Mortar hardens slowly but welding with the laser ray can be done in seconds.

The heart of a laser is a pink ruby rod of a synthetic crystal of corundum (aluminium oxide, an important ingredient of common clay) doped with chromium. An optical resonator forces the atoms to radiate in phase, resulting in a very narrow, interbeam of coherent light.

From *School Science and Mathematics.* **63** (8) : p. 671. Nov. 1963.

What is Celsius Temperature Scale?

Most thermometers are marked in either Fahrenheit or Centigrade degrees. There is a third scale called Reaumur named after the person who first proposed it. The Fahrenheit temperature was devised by the German physicist Gabriel D. Fahrenheit. This scale is used in United States and other English speaking countries for many years. The temperature scale used in most scientific works throughout the world was devised by the Swedish astronomer Anders Celsius (1701-1744). This fact is not so widely known because for many years this temperature scale has been called Centigrade (Centi = 100, grade = degree). Recently (1948) the International Bureau of Weights and Measures agreed to rename the scale after its inventor and to call it the Celsius temperature scale. Henceforth one has to read 45°C as 'forty-six degrees Celsius' and not 'forty-six degrees centigrade.' Fortunately both Celsius and Centigrade have the same first letter C. (see the article 'Our Units of Measurement-III elsewhere in this issue.)

S. D.

What is 'Silent Sound'?

The two words are contradictory. But there are sound waves of a frequency too high to be heard by the human ear. The technique which uses such sound is called ultrasonics. When passed through a liquid or solid the waves agitate the molecules and produce various chemical reactions. They can even destroy plant or animal tissue. Ultrasonics can also be used as a clearing agent. The water in

which the objects to be cleaned are agitated by sound waves; this produces millions of microscopic bubbles which thrust against the objects and break down dirt and grease particles. But an ultrasonic diswasher is still very expensive An ultrasonic 'whistle' has been devised which will control the thrust of a rocket by increasing or discreasing the rate of combustion of its solid fuel thereby permitting greater monoeuvrability.

Ultrasonics can also be used to sterilize milk and homogenize it. The waves break up the fat globules in the milk and at the same time destroy bacteria by breaking down their cell walls

Ultrasonic waves are also extensively used in medicine. It is believed they are capable of dissolving gallstones and some types of tumours. Bone cancers in animals have been destroyed through these means Ultrasonic waves were used to remove a human pituitary gland without recour e to surgery which is dangerous. The waves have been used to treat some forms of skin ulcers, vericose veins and other conditions.

By courtesy of the United States Information Service, New Delhi

Science notes

HORMONE TREATMENT HELPS DWARFED CHILDREN GROW

A hormone extracted from the pituitary glands of deceased humans is helping dwarfed children in the United States grow taller, so that they can lead normal lives as adults.

Scientists estimate there are many thousands of children in the world doomed to be dwarfs. Thirteen of these children, known as 'hypopituitary dwarfs' have been or are now being treated with injections of growth hormone in the Pediatric Endocrinology Clinic at John Hopkins University Hospital in Baltimore, Maryland.

The scientists say results have been phenomenal. One 14-year-old boy was the size of a normal 8-year-old when he began receiving injections two years ago. With continued treatment he is expected to reach an eventual height of five feet (1.5 metres) instead of the four feet (1.2 metres) which would have been his maximum growth without the hormones. Another boy, only 30 inches (76 centimetres) tall at age 7, grew 7½ inches (19 centimetres) during a 15-month period of treatment.

The 'investigative project', sponsored by the U.S. National Institute of Arthritis and Metabolic Diseases, is directed by Dr. Robert M. Blizzard. He said the major problem is that hormone from the glands of 200 to 300 persons is required to treat a single child. The pituitary is a pea-sized gland at the base of the brain. Attempts to synthesize the hormone have failed so far, and animal hormones are ineffective.

To increase the supply so that more children can be treated, a National Pituitary Agency has been formed to appeal to physicians and families of persons who have just died for permission to remove the pituitary gland during autopsy.

MACHINE DETECTS PRESENCE OF MINUTE AMOUNTS OF DEADLY GASES

A machine which detects deadly gases and dust particles in industry and space research has been developed by a United States scientist.

The machine was specifically designed to monitor the presence of poisonous boron compounds used extensively in rocket propulsion research. But the deivce can also be adapted to measure minute quantities of other toxic vapours such as chlorinated hydrocarbons, nitrogen dioxide and petroleum fuels.

The machine is so sensitive that within a few seconds it can detect the presence of as little as 10 parts of pentaborane in a thousand million. Even such a minute quantity can be toxic during an eight-hour exposure.

Operating on a simple principle, the machine pumps air through a gas pilot light. The flame is colourless until a contaminant passes. Then, a characteristic colour is observed, indentifying the toxic substance. For example, in the case

of pentaborane the flame becomes a faint green

A standard vacuum tube, called a photomultiplier, measures the intensity of the green which is then electronically translated to a metre. An alarm switch closes when the metre reading reaches a pre-set point.

The device was developed at the Illinois Institute of Technology's Research Institute in Chicago.

DEVICE IN SPACE RESEARCH ADAPTED TO TEST NEW DRUGS

An ultra-sensitive device designed for U.S. space research has an earthly application—testing the safety of drugs.

It was invented for use on a satellite to detect tiny particles of 'space dust', or micrometeoroids, and to find how densely they populate space.

Now, however, the U.S. Food and Drug Administration (FDA) has adapted the device to measure the effect of various drugs on the heart action of chick embryo. The ultimate goal is to use the instrument as a 'screen' or monitor to determine whether a new drug is safe for human use, or a pesticide safe for growing crops.

The device is an adaptation of a 'piezo-electronic transducer', the electronic component in a home hi-fi that picks up sound from a record.

Redesigned for space and medical research, it is so sensitive it can easily pick up the faint heart beat of a chick embryo inside the shell, or even measure the pressure of a light ray striking a mirror.

Vermon L. Rogallo, its inventor, and Dr. Jacqueline Verrett, who is conducting the chick embryo experiments, described the device and its potential at a news conference here. Mr. Rogallo is a scientist with the National Aeronautics and Space Administration's (NASA) Ames Research Centre in California. Dr. Verrett is a biochemist of the FDA's Toxological Evaluation Division in Washington.

The device translates minute pressures into electrical signals which can be converted into sound or into visual form for presentation on the screen of an oscillograph.

How sensitive is the new measuring device? NASA says it can measure one-one thousandth of the impact of a grain of salt falling one centimeter.

SMALL RADIO WITH INVISIBLE PARTS HELPS PILOTS NAVIGATE

A miniaturized radio receiver containing more than 25,000 components too small for the eye to see has been developed in the United States to help pilots navigate their planes with increased precision.

The 19-pound (8.55 kilogram) receiver known as 'AN/ARN-76,' which takes up only half a cubic foot (3,539 cubic centimetres) in the cockpit, helps a pilot find his position accurately to within a few hundred feet almost anywhere in the Northern Hemisphere

The system, which is a modern masterpiece of miniaturization, will be flight-tested in 1964.

Developed by the Sperry Gyroscope Company of Great Neck, New York, the system will gradually replace the so-called Loran-C receivers (the word 'Loran' is made up from the first letters of 'Long

Range Navigation') which are five times as big and heavy and are more difficult to operate.

The new units, like the old ones, help a pilot calculate his position by measuring the time interval between radio pulses broadcast from chains of strategically located transmitters on the ground. The system presently covers sea and land areas of the North Atlantic, North Pacific and Arctic Oceans and the Bering and Mediterranean Seas and is planned to be eventually extended on a worldwide basis.

Almost all of the circuits in the new receiver consist of tiny disks called 'silicon semiconductor wafers' each barely larger than the head of a match. These wafers are mounted in banks of 100 or more on post card size, plug in-units.

The system is so fully automated that engineers say it is easier to operate than a home television set. The new unit eliminates gears, motors, fans and other moving parts and has only five controls compared to 29 on the old units.

By courtesy : United States Information Service, New Delhi.

RADAR TO PREDICT RAINSTORMS

A radar system installed at the University of Melbourne, Australia, will provide warning of storms within a 200-mile radius of the city of Melbourne.

The University and the Federal Bureau of Meteorology will use the radar for research into rain intensity.

Built in Japan, from specifications provided by Australian engineers, the system can be operated from the university and from the city headquarters of the bureau.

The radar costs £60,000 and is one of a large number of installations which the bureau plans to instal at various locations throughout Australia in the next four years

The installations will provide information on the behaviour of the upper atmosphere winds and will assist meteorologists to compile forecasts for aviation and other public needs.

The equipment consists of a 12 ft. high radar pedestal and a 10 ft wide dish Its main function will be the detection of rain clouds up to 200 miles distance from Melbourne.

Weather forecasting in Australia is carried out on a national scale by the Federal Bureau of Meteorology Increasing use has been made of radar to enable meteorologists to predict what the weather pattern will be.

Sixteen radar units, known as wind-finders, will be installed at various weather stations and will be capable of measuring the speed and direction of winds up to a height of 120,000 ft.

In addition, eight radar units will be installed at Port Moresby, Papua—New Guinea, Willis Island in the Coral sea, at Kingsford Smith Airport, Sydney, New South Wales, Mount Gambier, South Australia and at Albany, Port Hedland and Broome, Western Australia.

These eight radars will serve the dual purpose of measuring high level winds and of detecting and tracking storms within a 200-mile radius.

By courtesy ; The Australian High Commission, New Delhi.

New trends in science education

Summer Institute Programme

EXTRACTS FROM DIRECTORS' REPORTS

IN all sixteen Summer Institutes were held from June 8 - July 15, 1964, four each in Biology, Chemistry, Physics and Mathematics for secondary school science teachers in the various universities. As reported earlier, the whole scheme was jointly sponsored by the National Council of Educational Research and Training, University Grants Commission and the United States Agency for International Development. 640 teachers attended the courses from all over the country. Each institute was manned by three or four professors or readers of the university where it was held and one of them acted as the Director Besides these, each institute had the services of two American experts, one a university professor and another a high school teacher. Both of them were familiar with the various modern programmes in the respective sciences and mathematics in their country. The names of these faculty members have already been reported in the earlier issue.

The materials followed in Physics, Chemistry, Biology and Mathematics were PSSC, CHEM-Study, BSCS, and SMSG, all being new methods evolved in U.S.A. The participants and the faculty members were supplied texts and materials brought to India particularly for this purpose.

Extracts from the report of the Directors of the several institutes are given below.

BIOLOGY INSTITUTES

Summer Institute in Biology—Delhi University

Two types of lectures were arranged—27 special lectures and 22 content lectures based on BSCS yellow version text. The former were mostly delivered by guest speakers who are specialists in their respective fields. The content lectures were delivered by guest speakers and Indian and American Faculty members. On each day there were two lectures followed by a discussion. In the afternoon there was a laboratory experiment from 2 to 4 P.M. and this was followed by discussion In all, the participants conducted 50 laboratory exercises. A few of them were even outside the laboratory manual The participants were oriented on the first two days towards the BSCS programme. This orientation proved very useful.

Discussions of various kinds, especially those following the content lecture and laboratory were the backbone of the institute. Two sessions were devoted to the discussion of the institute programme

and two to the implementation of the new programme in schools

The use of objective tests as teaching devices was discussed very frequently and the participants were asked to write one to three thought type questions following each content lecture and the laboratory work. Two tests were given by Mr. Fordyce and the participants were also asked to draft a set of questions. Several field trips were also arranged to take the participants to places of biological interest, to research institutes and other places.

The institute succeeded in orienting the participants to teach biology as an investigatory science. Several suggestions were made by the Faculty Members and the participants for improving the institutes in 1965.

The laboratory work proceeded in a systematic and smooth way. There was pre-planning and close co-operation between the American team and the Indian team. The laboratory supplies were adequate. While the participants were well-trained in qualitative biology, some time was devoted to stress the ideas of quantitative biology. This is where they got most of their new ideas, bases for establishing hypotheses, and experienced Biology as an investigatory science.

Summer Institute in Biology - Madras University Centre, Madurai

Forty-four participants, of whom 11 were women, attended the Summer Institute from the States of Andhra Pradesh, Mysore, Kerala and Madras. Two of them were from Bhubaneshwar and Delhi. Their teaching experience varied from 1 to 26 years, and the ages 25 to 50. There was adequate accommodation by way of laboratory, lecture rooms, seminar room, projection room and common room

The institute started every day functioning from 9 A.M. and continued till 5 P.M. The morning session was devoted to discussions and lectures and the afternoon session was devoted to laboratory work and films About 30 hours were spent in lectures. The number of lectures were cut down to the minimum. There were more discussion sessions. Over 46 experiments were performed in the laboratory. These experiments included those outlined in the laboratory manual of the 'yellow version'. Besides these, about 15 experiments outside the 'yellow version' were devised and conducted. Some of these were on, aerial biology, effect of turmeric and neem on growth of microbes, culturing of yeast from cooked rice soaked in water, effect of colour on photosynthesis, rate of heart beats of a fresh water mussell, blood typing, preparation of stages of cell division in root tips using colchicine, and several other experiments As far as possible the experiments were performed with locally procurable material and were adopted to the local conditions.

The laboratory blocks were introduced and an opportunity was given to participants to try the effect of testesterone on the secondary sexual characters of chicks. Under the scheme of projects for participants, an opportunity was given to them to plan and conduct their own laboratory exercises. The participants showed a good deal of interest in 'Invitations to Enquiry'. With the guidance of Mr Thomas the participants tried their skill in making simple molecular models.

At least one hour was spent every morning for discussions. One session was devoted

to discuss the methods of implementing the new approach with the existing syllabi. Dr. Hill of the T.C.C.U Team introduced the objective tests. There were several field trips to (i) Alagarkoil (ii) Gandhigram (iii) Kodaikanal and Viagai Dam. About 10 special lectures were arranged where experts addressed the participants.

Another novel feature of the institute was the decoration of the commonroom with pictures of basic themes of BSCS approach. Some of these were the DNA molecule, cell, becteriophage and a haemoglobin molecule A model of DNA molecule was made locally and was also on display. This display and decorations enthused the participants and kept the principal aim of the training always in the forefront

Summer Institute in Biology–Bombay University

As a rule there was one lecture everyday by a member of the faculty specialized in the topic. Following the lecture the participants were split into two groups one of which discussed the lecture and the other worked on 'Invitations to Enquiry'. After one hour the groups exchanged. In the later phases the trainees were made to take over the 'invitations' under supervision. The laboratory work in the afternoon was followed by discussion Certain running experiments like those on population genetics, spontaneous generation, physiology and bacteriology were carried out. The day's programme generally ended with a film show or a lecture by an invited guest.

The novel feature of the institute was the choosing of a research problem by each participant in the last week of the course. The object was to initiate the participants in the technique of research and the problem was of a type which could be continued by the trainee in his own school with the apparatus and chemicals available to him. There were also a number of field trips.

Laboratory reports, performance while presenting 'Invitations to Enquiry' and the two objective BSCS type examinations were used for internal assessment The participants were also encouraged to frame test papers. The results of a final test indicate that the students were better able to handle this kind of test at the end than at the beginning of the institute

In all 22 lectures were delivered and about 35 laboratory experiments were conducted The participants learnt to recognise that learning is a two-way process and that student participation, students' inquiry and mutual discussion are much better than the lectures Among the suggestions made are one, that in future there should be some institutes at district levels in addition to the zonal institutes. The BSCS material should be modified to suit Indian conditions Institutes should be held during the vacation period not clashing with the working of the University or college where it is conducted. The American staff should be with the Indian staff at least a week before the start of the Institute.

Summer Institute in Biology—Utkal University, Cuttack

Adequate accommodation consisting of a lecture theatre, laboratories, library and hostel was provided. Besides the regular lectures and laboratory exercises about seven special lectures were delivered by specialists from the Rice Research Institute and the university. Of particular interest was one by Dr. J. B. S Haldane and another by Dr. P. N. Ganapathi of the Andhra University. The Director has

analyed the answers given by the participants to a questionnaire.

PHYSICS INSTITUTES

Summer Institute in Physics—Banaras Hindu University

There was daily discussion for one hour held in four groups each headed by a Faculty member. The evaluation and marking procedures included such items as use of tests as teaching devices and preparation of tests In the afternoon, there was laboratory work from 3 to 5 P.M One lecture a day was held in the morning and special lectures were held in the evening. There were also film shows. Altogether 20 experiments were performed and ten demonstrated. These were all according to the PSSC guide.

There was a strong agreement that the syllabus must be changed to follow the PSSC text. Other comments were: thorough revision of examination system, provision of supplies and equipments for teaching and provision of sufficient space and teaching time to do an adequate job.

The laboratory experiences were ranked first among the strong points of the institute; the films and lectures came next. The use of tests for the participants were not liked. The participants desired more opportunities for informal discussions of their opinions and difficulties A variety of improvements in teaching methods were suggested. This included frequent use of graphs, discussion groups and the reduction of emphasis on memorisation. Science Clubs and class instructions were both mentioned fairly often as means of approach. A strong expression was given for the development of a system of communication, between participants and staff members of the Summer Institutes. A publication on new teaching methods and new science developments was specifically requested by several. Production of kits for laboratory development was important to many. They also desired to have visual aids, supplementary books and a postal system for teacher guidance.

An interesting guidance was sounded that in the years ahead we do not allow a state of fixed laboratory activities to become so ingrained that this can serve as a syllabus goal for the laboratory and thus act to paralyse development as the present class syllabi do.

The experimentation was carried on enthusiastically by all. The desire for a workshop and the presence of instructor was quite real. The participants wanted to learn how to construct, repair and improvise.

Summer Institute in Physics Ahmedabad

Thirty-eight experiments of PSSC course were done by the participants Five tests were given and the tests were used as teaching device only The participants were asked to submit questions which they did.

Almost the entire PSSC text was covered by means of lectures and 50 PSSC films were screened.

Summer Institute in Physics—Gauhati

Most of the lectures were given by the teachers of the Cotton College. Most of the experiments in the PSSC laboratory type were performed except eight It was felt desirable to do fewer experiments more thoroughly than to attempt a very large number of experiments. The laboratory programme was quite a success

According to the participants, the most valued experience was the laboratory

programme; the problem-solving and discussion sessions followed next in rank. Every participant indicated a recognition of the need to adopt the new approach. About two thirds of the participants indicated that they could introduce some new content or a new approach. They mentioned Science Clubs as a means of introducting laboratory experience.

Summer Institute in Physics—Karnatak

All the PSSC experiments except about 18 were conducted by the participants. Most of the chapters in the PSSC text were covered in the form of lectures. The laboratory with some 30 typical PSSC experiments with one participant for each experiment was kept open to science teachers of secondary schools of the neighbourhood on July 12, 1964. The American staff and the Director met the students informally for one hour at the end of the institute to obtain the views of the participants.

CHEMISTRY INSTITUTES

Summer Institute in Chemistry—University of Burdwan

Everyday there was one lecture, and a discussion for two hours in the morning. In the afternoon there was a three-hour period of laboratory work and pre-laboratory and post-laboratory discussions. In the evening there were film shows on some days. The participants were divided into two laboratory groups; and two participants jointly performed experiments In all 31 lectures were delivered and 25 laboratory experiments conducted. Four objective tests and achievement tests were given. The participants were also asked to prepare objective tests. The work on each laboratory exercise was corrected by a teacher and suggestions for improvement and correlation of data, use of graphs and interpretation of the graphs were made. There were two field trips arranged. There was a conference of headmasters and science teachers of the locality, where the new methods were discussed. A summary of the participant evaluation reports has been prepared. The outstanding strengths of the institute were classroom lectures and discussions and organization of laboratory work and close rapport between participants and faculty members The weakness of the institute was that full utilization of the facilities of the Institute was not made as one-third of the participants did not turn up. There was scanty secretarial assistance.

Summer Institute in Chemistry—Osmania University, Hyderabad

There were ten lectures by prominent scientists each of which was followed by discussion. The regular lectures and the laboratory exercises were organized by the Indian Faculty members in close consultation and co-operation with the American consultants. Films were shown in the morning for one hour. On Saturdays there were group discussions with the participants. There were five such discussions. The discussions were followed by critical evaluation by Prof. M. Tamres.

Three open book examinations were held to evaluate the reaction of the participants to the content of the syllabus The participants got an idea regarding the design of questions for an open book examination. The objective tests were at first prepared by the American Faculty members and this was closely followed by Indian members subsequently. The pro-

gress achieved in the evaluation test was satisfactory. An average of 50 per cent increased to 61 per cent in the second book examination. In the final examination also the average grade was 64 per cent and the highest grade obtained was 97 per cent. There were five field trips arranged. Everyday there were two lectures followed by discussions and there was a laboratory assignment for three hours in the afternoon. The special lectures were arranged in the evenings.

Summer Institute in Chemistry—University of Poona, Poona

Everyday there were two periods on theory from the CHEM-Study text and one period of discussion on the experiments done. 36 laboratory exercises were conducted and 17 chapters of the text were covered in theory. After the experiments, everyday there were discussions on the particular experiments. There were two field trips arranged. Regular CHEM-Study objective tests were also applied. Among the suggestions for improvements in the next Summer Institute are :

1. That the syllabi should be modified according to the new method.
2. The first 13 chapters of *Chemistry—An Experimental Approach* may be dealt with in the secondary schools, while chapter 14 onwards with addition of parts 3, 4 and 5 from CBA may be included in the pre-degree course.

Participants in their reports state that evaluation by tests will not be proper due to limitation of time and the difficulty to come down to the students' level. To some extent the new method of teaching can be introduced in the present syllabus itself. However, limitation of time and availability of laboratory facilities are the major difficulties. There should be more demonstrations and guidance in the Science Clubs. A Summer Institute in General Science is also essential

Summer Institute in Chemistry University of Rajasthan, Jaipur

Thirty-nine teachers including 6 women teachers from four States joined the institute. Most of the participants had a postgraduate degree. The morning hours were devoted mainly to practicals and discussions. The afternoon was devoted to discussions on text chapters, quiz programme, films on CHEM-Study and general lectures. Some of the talks were successful in modifying old basic concepts, for example, atomic weights based on carbon 12, compounds of inert gases, role of ionization potential and electron affinity on the periodicity of properties of elements Participants divided themselves into groups to discuss :

1. the ways and means of applying the new programme in laboratory work in their schools,
2. new lecture demonstrations as tools of instruction, and
3. improvement in the teaching of basic theoretical concepts.

Thirty-seven experiments were performed and 17 to 18 chapters of the text were covered. More than two dozen classroom demonstrations including some by the participants were held. 30 films were shown during the course of the institute. A number of chapter tests and CHEM-Study achievement tests were administered.

Group Discussion Report : It was felt that part of the training and experiences gained in the institute programme could be used even in the present set-up. The

participants set themselves to examine what particular ideas, experiments, concepts they might take home and use. It was felt that the laboratory manual of the CHEM-Study material is very suitably planned to arouse inquisitiveness in students, sharpen their power of observation to place the student in a position to get the thrill or joy of discovery. It was also felt that most of the experiments in the laboratory manual could be covered by the students of higher secondary classes. The report lists such of those experiments which can be done in Classes IX, X, XI. It was suggesed that the films should be dubbed in Hindi if they were to serve a more useful purpose. It was strongly felt that some of the new concepts such as molar concentration, uncertainty factor in measurements, oxidation number, etc. could be introduced at the school level. The report also gives the chapters and articles from the text which could be accepted in our present set-up. There is also a list of those topics that do not come under the purview of many of our present syllabi.

MATHEMATICS INSTITUTES

Summer Institute in Mathematics—Kurukshetra, University—Simla

Two courses of lectures were given, 24 lectures on geometry and 12 lectures on algebra. Two speakers also spoke on interesting subjects. There were two joint sessions with the Summer Institute for college teachers of mathematics, also held at Simla. There were general discussions in the afternoons which were led by Mr. Pereire. All the participants took part in this. There was one discussion session devoted to objective tests. There was no marking of the papers but the answers were discussed Everyday there were two lectures in the morning followed by informal discussions. In the afternoons there were general discussions based on SMSG material. There was also a meeting with the Textbook Panel which was meeting at Simla at that time. All the members of the Panel visited the Institute and some of them gave talks to the participants. An Association of Mathematics Teachers was formed and the other centres are being requested to form similar associations where the new spirit in mathematics teaching could be discussed.

Faculty evaluation report: In the programme of lectures, ample time was provided for questions and discussions. The afternoon sessions were divided to pedagogical problems such as implementation of new programme, testing methods and methods of presenting a topic in the new contest. The small group discussions were held in a more intimate relationship Participants who would otherwise have been silent asked questions and also discussed problems.

Summer Institute in Mathematics—M.S. University of Baroda—Mount Abu

Each working day was divided into two sessions There were two lectures in the morning followed by a discussion lasting half an hour. 45 lectures in all were given. In the afternoons, seminars were held from 2-30 to 4-30 P.M. Various activities were undertaken in these seminars. Participants were divided into five groups, each selecting its own leader. The groups prepared reports and also gave five demonstration lessons.

Summer Institute in Mathematics—North Bengal University—Darjeeling

In the morning sessions there were two one-hour lectures, each followed by dis-

cussions for half an hour. In the evening there were critical discussions on SMSG texts and occasionally discussions on examination system, syllabus and methodology led by Dr. Grossman. For half an hour, Dr. Grossman replied to questions by participants on school education. In the evenings there were lectures by members of the Indian staff. There were a few objective tests. It was strongly felt that unless the teacher's status was increased and the examination reform went hand in hand with revision in syllabus, it would be very difficult to implement the new methods of teaching.

Summer Institute in Mathematics—Mysore University, Mysore

Thirty-nine teachers from four States attended the Institute. There were two lectures in the morning followed by group discussion from 2 P.M. to 4 P.M. The latter were led mostly by Dr. Shaaf whose illuminating talks on teaching mathematics had a very good response from the participants. Two tests were given by Dr. Shaaf and two take-home exercises were given by Dr. Berri.

SOME FIGURES ABOUT THE SUMMER INSTITUTES

The enrolment, state-wise, is given in the following table:

State	*Biology*	*Chemistry*	*Physics*	*Maths.*	*Total*
Uttar Pradesh	13	9	15	18	55
Delhi	12	12	13	15	52
Panjab	8	11	9	16	44
Rajasthan	10	16	19	11	56
Madhya Pradesh	8	10	13	14	45
Gujarat	4	6	9	6	25
Maharashtra	14	14	13	11	52
Andhra Pradesh	20	20	12	16	68
Kerala	11	10	14	9	44
Madras	7	3	6	4	20
Mysore	6	14	12	10	42
Orissa	23	3	8	17	51
Bihar	3	3	9	7	22
Assam	10	8	15	7	40
West Bengal	4	8	3	8	23
NEFA	—	1	—	—	1
Total	153	148	170	169	640

Out of 640 participants, 41 were lecturers in PUC/Intermediate classes, 23 were lecturers from training colleges and 4, lecturers from Regional Colleges of Education of the NCERT. The remaining 588 were teachers from High/Higher Secondary Schools.

Out of the 757 names recommended by the DPIs only 365 submitted their applications and 311 actually attended

the institutes. The remaining teachers i.e., 329 came from Central Schools, Sainik Schools and schools recommended by the DEPSE as well as private schools.

Out of the 640 teachers, 153 attended the Biology institutes, 148 Chemistry institutes, 170 Physics institutes, and 169 Mathematics institutes.

SUMMER INSTITUTE IN BIOLOGY—DELHI UNIVERSITY

A PARTICIPANT'S REACTIONS

For most of the participants the Summer Institute was a novel experience. None of the participants knew what was to be done there and, in a way, it was a leap in the dark. However, Dr. B.M. Johri, the Director of the Institute, had given a hint that strenuous work would be required and that the Institute was for the improvement in the teaching of Biology at the Higher Secondary stage.

The first two days were spent in orienting the participants to the new methods of teaching biology (BSCS) in the light of enormous advances in life sciences. The participants fully realized, as they had already been doing to some extent, that something must be done and a beginning had to be made.

The full implications of the programme could not be understood immediately but as time passed it was brought home to the participants that it was a revolutionary approach to the teaching of biology. It was a way of thinking and acting far removed from the conventional or traditional procedures.

The participants found themselves in the very thick of affairs from the day the Institute commenced and they continued in the same way up to July 13. Week-ends were devoted to excursions. The excursions were not allowed to deteriorate to mere sight-seeing.

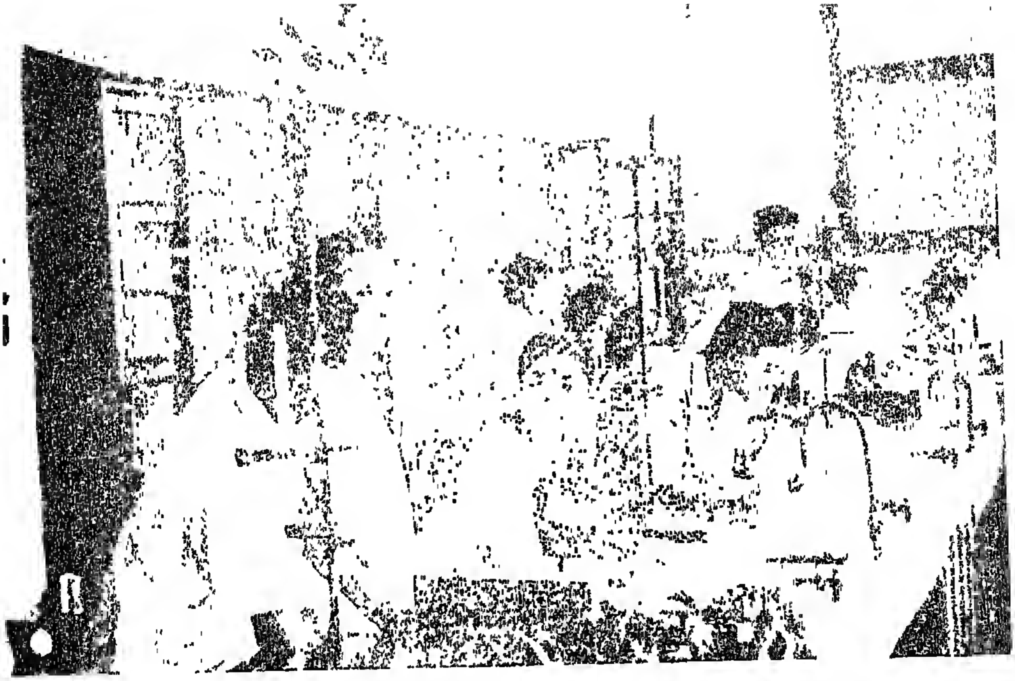
There cannot be two opinions about the fact that the Institute has been of tremendous benefit to the participants. They have not only learnt a new technique but have also been acquainted with the latest advances in biological sciences. They have fully realized that the traditional curriculum and methodology would be of no avail and would not be able to produce biologists who might be able to rub shoulders with their counterparts in other countries. Whereas, the methodology is in the hands of teachers and they can make innovations and adopt investigatory and exploratory techniques as envisaged by the BSSC programme, the curriculum and examination system do not lie in their purview. This is the responsibility of Education Departments of various States. Unless they realize the far reaching implications of the new programme, remove the dull and dead matter from the curriculum and include more important recent advances, the teacher in spite of his best efforts and enthusiasm would be able to make little headway.

Along with the change in syllabus the examination system also needs a thorough overhauling. As is well-known, the examination system at present has reduced all teaching to memorization and reproduction on the part of students and doling out well-organized and judiciously apportioned matter to students on this part of teachers. This must be changed soon, otherwise the teachers may find to their chagrin that their efforts have gone to waste.

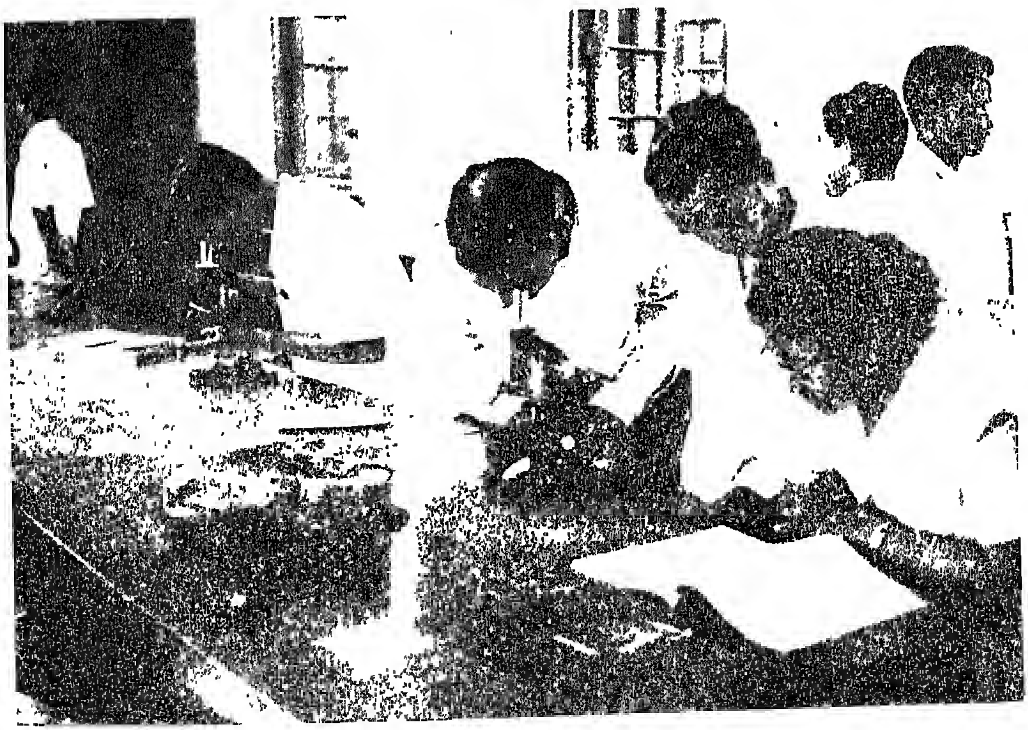
A.K. ROY

Summer Institute in Biology, Delhi—Participants at Laboratory work

Summer Institute in Biology, Delhi—Point of discussion with the Director



Summer Institute in Biology, Cuttack—Participants at work in the Laboratory



Summer Institute in Biology, Cuttack—Some interesting feature under the microscope

News and notes

SCIENCE TALENT SEARCH

THE results of the Science Talent Search Scholarship Examination, 1964 were declared and 354 students were found eligible for the award of scholarships as well as certificates of merit. The next 186 students were found eligible for the award of certificate of merit only. All these students will be awarded the badge having the crest of the National Council of Educational Research and Training and the engraving 'Science Talent Search Scholars 1964'. Autobiographical sketches of the awardees have been collected and printed under the caption 'Scientists of Tomorrow'.

Some selected essays in science witten by students at the essay test have also been printed for distribution to all the secondary schools in India so that the students and teachers of science may be motivated in the academic sphere. A factual report has been prepared which gives statistical details of the functioning of the entire scheme with a view to formulate future programme of follow-up.

Preliminary arrangements are being made for holding workshops at five or six different centres in India where the talented students will be brought into contact with the eminent teachers of the universities in various basic sciences. Steps have also been taken to popularize the Science Talent Search in the country and the application forms and brochures have been issued all over the country for being transmitted to the eligible candidates.

SEMINAR OF SCIENCE CONSULTANTS

The Second National Seminar of Science Consultants was organized in June 1964. The results of the Seminar are as follows

(a) Review of the scheme of Science Consultants work done, difficulties encountered and remedies for the same; consolidation and expansion of the scheme.

(b) Scheme for the improvement of elementary science to be included in the 4th Five Year Plan. Recommendations were made for the following items and their financial implications were worked out on All-India basis.

i. In-service training programmes for primary and middle school teachers.
ii. Improvement of teacher training programme at the elementary level
iii. Development of science laboratories in middle schools.
iv. Orientation of Inspectors.
v. Orientation of the science staff of the State Institutes of Education.
vi. Organization of science clubs in primary and middle schools.
vii. Production of supplementary reading materials in science.
viii. Establishment of science museums.
ix. Expansion of Science Consultants scheme.
x. Implementation of recommended schemes.

(c) A guide-book for teaching science in primary schools—First draft was prepared at the Seminar and is being reviewed

at the Department before it is sent for publication

BIOLOGY TEXTBOOK PANEL

Section I of the book *Biology—A Textbook for Higher Secondary Schools* prepared by the panel has been printed. It deals with 'Some basic facts about life' spread over nine chapters. Section II is ready for press and the materials on other Sections will be made ready for the press very soon. The Central Board of Secondary Education, Delhi, has prescribed the book for use in the higher secondary schools under the Board commencing from the sess on 1964-65. After the books are tried for a year and in the light of suggestions invited from the teachers the text will be revised and produced as a single bound volume.

SUPERCONDUCTING SEMICONDUCTORS

Ordinarily every substance offers resistance to the flow of electricity. The electrical conductivity of a substance depends on the number of free electrons in the outermost shells of its atoms. The metals are good conductors as in their case the number of free electrons is large, whereas insulators have tightly bound electrons and are poor conductors. In 1911, Kamerlingh Onnes discovered that at a temperature of about 4.2 absolute the electrical resistance of solid mercury decreases sharply and becomes practically zero. Such a substance was termed a superconductor, and the phenomenon of complete disappearance of electrical resistance at temperatures near absolute zero as superconductivity. Since then many other metals and metallic compounds have been found to be superconductors.

Besides the conductors and insulators, there is yet another category of substances in whose case the concentration of free electrons and hence the electrical conductivity is somewhere between that of metal and that of an insulator. Such substances known as semiconductors are considered to have too few free electrons to be superconducting. Moreover, their electrical resistance increases with decrease in temperature. Last year, however, Marvin L. Cohen, a graduate student at the University of Chicago, suggested on the basis of his studies that semiconductors might also be good superconductors. Cohen's prediction has been confirmed this year by the discovery of superconductivity in two of the semiconducting materials germanium telluride and crystals of strontium titnate.

The new finding can be expected to affect considerably the future studies of superconductivity for the simple reason that more work has already been done on the semiconductors than the metals. It may then be possible to answer the questions like 'whether or not the substance is superconductor', 'at which temperature will the substance become upereonducting'.

Books
For your science library

Vistas of Science: Produced by the National Science Teachers' Association. Scholastic Book Services, Division of Scholastic Magazines, Inc, New York, N.Y. Price per book 50c.

IN this present age new discoveries, important applications, and major break-throughs continue to widen our vistas of science, engineering and technology. These expanding frontiers produce an impact on society and more and more young citizens seek careers in science, and people of all ages seek a better understanding of the scientific advances. To satisfy these things the National Science Teachers' Association of the United States has started the production of a series of books under the feature 'Vistas of Science'. In initiating this programme they also aim to improve science teaching in schools. The books also provide scientific background for those who are well informed.

Eight books have been published so far, each dealing with a specific area of science, such as, spacecraft, astronomy, microbiology and chemistry of life. The books constitute useful science resource and enrichment literature, written for junior and senior high school students and of value to teachers and others.

The authors are scientists, science writers and classroom teachers of rich experience and skills. These books will be useful additions in any school library. The contents and the area of science treated in seven of these books are given below.

Spacecraft. James J. Haggerty, Jr., and John H. Woodburn. pp. 160, 1962.

MANY studies on the space, and several achievements in launching spacecraft have been made. In this book are described America's plans for space exploration, and the immediate applications of space technology in the fields of weather prediction, communications, navigation, solar and astronomical observation. In the last few pages the book has a chapter on ideas for projects and experiments which the student can do.

Experimentation and Measurement. W.J. Youden pp.128.

THIS is a project book introducing the laws of statistical measurement. There is only one way to learn the laws and techniques of scientific measurement and this is *to make measurement*. The book contains a series of fascinating experiments and methods to make instruments, calibrate them and put them to work. There are illustrative charts, diagrams and graphs to serve as practical reference guides for the

students' interpretation of laboratory data.

Frontiers Of Dental Science. C. C. PAFFENBARGER and SHOLOM PEARLMAN. pp. 160, 1962.

THIS book gives a very illuminating survey of the complex integration of sciences—anatomy, embryology, physiology, biochemistry, genetics, microbiology, pharmacology, biophysics, physics, materials research and anthropology that characterize modern dental science. As you read the book you will gain rare insight into processes and the scope of science as a whole.

Challenge of the Universe. J. ALLEN HYNEK and N.D. ANDERSON. pp. 144.

THIS is a fascinating book of facts, theory and speculation on the science of *astronomy*. *Dr. Hynck propounds* a theory of life on other planets and discusses the possibilities of introducing plant life into Venus by air conditioning that planet. The projects include instructions for building simple theodolites and spectroscopes. There is a chapter on relativity which shows, 'Why man is for ever limited to one infinitesimal sector of the universe?'

Microbes and Men. H J. SIMON. pp. 160, 1963.

THIS book will help the reader in becoming acquainted with many microbes, and with the measures scientists use to control these. This is a lively up-to-date introduction of microbiology for the high school students The author discusses bacteria, infection, disease and even the latest principles of chemotherapy and antibiosis. At the end there are projects and experiments.

Chemistry of Life. KATHERINE B. HOFFMAN and ARCHIE L. LACEY. pp 128, 1961.

UNDERLYING all life are bits of non-life atoms and molecules, elements and compounds, which the biochemists have ventured to explore in order to answer, 'What is life?' The book explains the latest advances in molecular biology and the chemistry of the cell, as well as the concepts and processes behind these advances. One is left standing where the roads of biology and chemistry merge into the broad front of biochemistry.

The Lore of Living Plants. JOHANESVVAN OVERBEEK and HARRY K. WONG. pp 160, 1964.

THIS deals with the story of the living plants, particularly plant physiology. *The Lore of Living Plants* follows the energy of sun from its capture by the leaves its final appearance in fruit and seed at harvest time. Why do some plants flower in spring and some in the fall, and why do trees shed their leaves? There is a good discussion of what functions physiological processes serve and what needs these processes fill in the plants. As most plant activities are taking place at the molecular level, this approach has been followed in some places where it was found necessary—to describe the exciting discoveries made in chemistry and the electronics.

S. DORAISWAMI

Problem Solving in Chemistry. GLEN Tilbury, Lyons and Carnahan, Inc., U.S.A.

THE book deals with problems in metric system, significant figures, atomic weights and molecular weights, moles, gas laws, percentage composition of solutions, gram-equivalents, titration of acids and bases, dilution and other problems in elementary chemistry.

A large number of problems have been solved and problems to be worked out by pupils are given. All the steps needed in a solved problem are given distinctly and there is no possibility of confusion in understanding them by students. Helpful diagrams have been given here and there as an aid to understanding of the solution of problems.

Between the Planets. FLETCHER G. WATSON, Harvard University Press, Cambridge, Massachusetts, U.S.A.

THIS book surveys the solar system and deals with planets, whirling fragments, anatomy of a comet, shooting stars, meteor showers and interplanetary materials. The book also provides figures for solar distance, Interval to Perihelion and temperature for parabolic orbits.

The language is simple, and the matter has been presented in a very interesting way.

V.N. WANCHOO

A New Look at Gravitation

J. V. Narlikar,
King's College, Cambridge

MODERN physics can be said to have begun about three centuries ago with Newton's law of gravitation. Yet gravitation remains, to this day, one of the least understood phenomena in physics. Last week, Fred Hoyle and I proposed a new approach to this problem. The point of view leading to the present theory can be best described in the background of the evolution of physics since Newton.

Newton formulated his law in the form of action at a distance. The force of attraction between two material particles is proportional to the product of their masses and inversely proportional to the square of their distance apart. The constant of proportionality, the gravitational constant G, was determined by experiment. The remarkable successes of this law accustomed physicists to think in terms of instantaneous action at a distance; and when electromagnetism was discovered, it too was described in terms of action at a distance.

However, it soon became clear that instantaneous action at a distance did not give a complete description of electromagnetism—especially where non-steady phenomena such as radiation were concerned. The indication was that action should propagate with a finite speed. In a letter on 19 March 1845, the German pioneer of electromagnetic theory, J.K.F. Gauss wrote:

'I would doubtless have published my researches long since were it not that at the time I gave them up I had failed to find what I regarded as the Keystone.... namely the derivation of the additional forces—to be added to the interaction of electrical charges at rest, when they are both in motion—from an action which is propagated not instantaneously but in time as is the case with light.'

The failure to give a mathematical description was largely due to the fact that special relativity had yet to come and physicists were not accustomed to thinking of interactions travelling with a finite speed.

The problem was solved, though in an entirely different way, by Maxwell in the 1860s. Maxwell's theory, the first field theory in physics, gives a description of electromagnetism in terms of charges and electromagnetic fields. The motion of a charge is given by the value of the field at that point. The fields are related to the motion and distribution of charges by Maxwell's equations. The important point is that the field theory is local in character—in direct contrast to action at a distance. In Maxwell's theory, two charges interact, not directly, but through a field. Any disturbance in the electromagnetic field propagates with a finite speed, the speed of light.

Reprinted from, *New Scientist* **22** (396) : 730-732, June 1964, with the kind permission of the Editor.

The success of Maxwell's theory heralded a new era in physics. Action at a distance fell into disrepute and fields came to stay. Maxwell's theory also served as the forerunner of the special theory of relativity. Maxwell's equations, which at first looked rather cumbersome in the 19th-Century notation which separates space from time, took on new elegance when expressed in the four-dimensional form of special relativity.

Newtonian gravitation, with its instantaneous action at a distance which had proved so attractive and successful before, now looked inconsistent with the ideas of field theory and special relativity. In formulating his theory of gravitation, known as general relativity, Einstein therefore looked for a field theory.

Unlike electromagnetism, gravitation has the property of 'always being there'. The electric field of a positive charge can be cancelled by that of a negative charge. A similar cancellation cannot be effected in the case of gravitation. Einstein interpreted this result to mean that gravitation is the property of space-time

In Einstein's theory, the presence of gravitation alters the geometrical structure of space-time. Thus, instead of saying that planets move in elliptical orbits round the Sun, we should say that they move in 'straight' lines, but the rules of geometry which determine what is a 'straight' line are changed. In other words, the rules of Euclidean geometry do not hold. Einstein's equations describe how the geometry is modified by the presence of matter.

There is a clear analogy with Maxwell's theory, in which matter can be likened to electric charges, and the variables describing the non-Euclidean nature of geometry are comparable with the electromagnetic fields. It turns out that, when the gravitational field is not very strong, Einstein's equations reduce to Newton's.

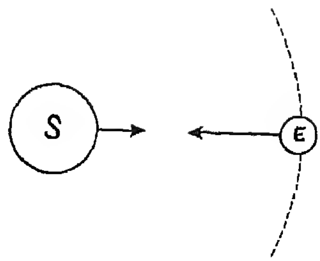
In spite of the successes of field theory, sporadic attempts to revive action at a distance were made in the early part of the present century. The problem which baffled Gauss was finally solved by Karl Schwarzschild, H. Tetrode and A.D. Fokker. Fokker was able to express, in a precise mathematical form, the concept of action between two electric charges propagating at the speed of light. This theory, however, met another stumbling block, which can be described in the following way. Imagine two charges, A and B, situated one light-hour apart. The action leaving A at, say, 5 A.M. gets to B at 6 P.M. The theory then predicts that B's reaction to A leaves B at 6 P.M. and reaches A at 5 P.M. There is thus a lack of causality here. How can one reconcile such a theory with experience?

This difficulty was resolved in a very elegant manner by J.A. Wheeler and R.P. Feynman about twenty years ago. They argued that the universe does not contain just two particles. In the above example, one must add the reactions of all the remaining particles C,D,E..... in the universe. They demonstrated that, when all the reactions are added up properly in a static universe, the result given by the theory does indeed accord with experience. In doing so, they also cleared up one problem which had remained unsolved in Maxwell's field theory. This difficulty was associated with the 'self-action' of an electric charge.

Experience shows that, when an electric charge oscillates, it radiates energy to the universe and as a result suffers a damping of its motion. This damping arises from the motion of the charge itself and is known as self-action. Now, it is possible to give a description of this phenomenon within the framework of Maxwell's theory. But owing to its time-symmetry, the theory also predicts the reverse phenomenon, in which an oscillating charge gains energy from the universe. Why does nature make an arbitrary choice in favour of the former? Moreover, the formula for self-action can lead to absurd results such as infinite self-acceleration of an electric charge. How is this to be avoided?

Both these questions are answered by the Wheeler-Feynman theory. The concept of self-action is replaced by that of reaction from the universe, and the awkward infinities do not arise. Moreover, the choice in favour of radiation and damping is not arbitrary, as in the field theory, but is accounted for by the interaction with the universe.

In their calculations, Wheeler and Feynman had assumed the universe to be static, and therefore inherently time-symmetric. In order to get their result they had to introduce a time asymmetry by making particular assumptions about the initial conditions. J.E. Hogarth showed that 'dodge' to be unnecessary. He argued that the required asymmetry did not have to be postulated but was indicated by observations; the universe is not static but is expanding. The Wheeler-Feynman theory should therefore be worked out in an expanding universe. This calculation was done by Hogarth and later, in a different form, by Hoyle and myself.



The idea of action at a distance; two objects for example the Sun and the Earth interact with one another directly across a great distance. At first it was thought to be instantaneous.

The idea of a field: the Sun (and the Earth, too) is surrounded by a gravitational field of force. The Sun's field, not the Sun itself, acts on the Earth.

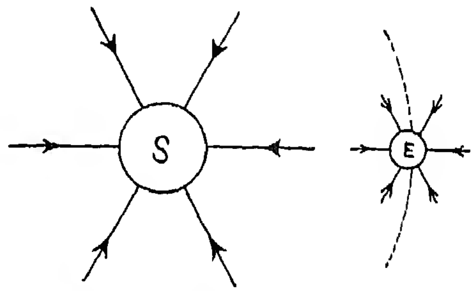


Fig. 1. Action at a distance, or field?

It turned out that the result of the calculation depends critically on what model of the universe is assumed. We found, for example, that results in agreement with experience (and causality) follow in the steady-state universe (which is essentially uniform and unchanging in space or time) and not in the 'big-bang' Einstein-de Sitter universe (which is finite and evolving).

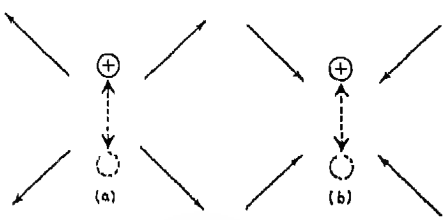
We were very impressed by this result. The action at a distance theory had not only cleared its old obstacles but had also proved more informative. It became possible to draw conclusions about cosmology from apparently local phenomena. This has never been possible in a

field theory, which only relates purely local quantities.

If action at a distance is a fruitful way of looking at electromagnetism, there is no reason why it should not be extended to other parts of physics. We were soon able to express the C field, which describes the continuous creation of matter required by the steady-state theory, in the form of action at a distance. We were then encouraged by this success to consider gravitation.

The idea that local behaviour of matter is influenced by the distant parts of the universe was put forward by the philosopher Ernst Mach in the last century and is known as Mach's principle. Various physicists have interpreted this idea in different ways. Einstein himself was greatly impressed by it and had hoped that it would be incorporated in general relativity. His ambition was not realised and one of the main reasons was the inherent field-character of general relativity. Mach's ideas, as was seen above in the case of electromagnetism, can be incorporated more directly in a theory of action at a distance

In our approach to gravitation we have followed the Einstein view that gravitation



Time-symmetry: We know that an oscillating electric charge radiates energy to the universe as in (a), and loses energy. In Maxwell's electromagnetic theory, it is just as plausible that the oscillating charge should **gain** energy from the universe—the film could, as it were, be run backwards. To be convincing, theory has to exclude (b).

Fig 2. The bugbear of time symmetry

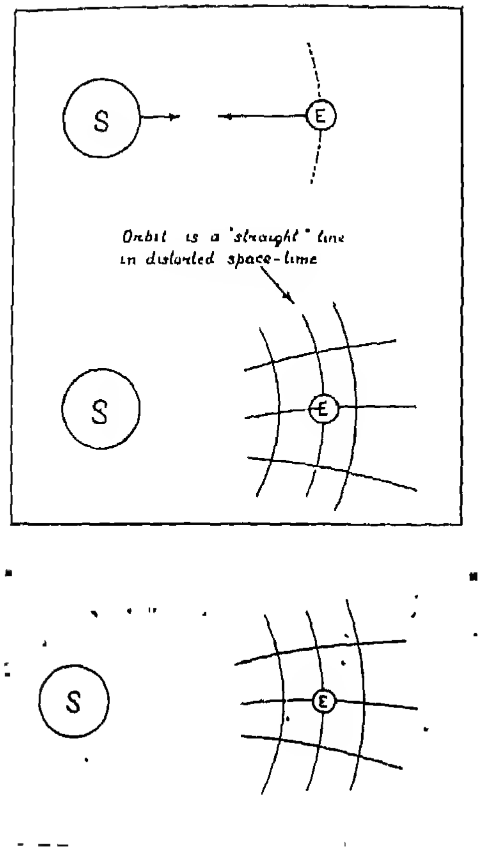
is to be attributed to the non-Euclidean geometry of space-time. The difference comes in the interpretation of the inertial mass of a particle. In general relativity, this is the intrinsic property of the particle; in the present theory, mass arises from the rest of the particles in the universe. Following the analogy of electromagnetism described above, it is possible to give an expression for the mass of the particle in terms of the rest of the particles in the universe.

The gravitational equations are derived from the principle of stationary action (sometimes wrongly called 'least action'). This mathematical principle has, in the past, proved immensely useful in the derivation of new physical laws. In the present case this principle states:

The actual space-time structure is such that if we alter it slightly (in an arbitrary way) the action describing various physical phenomena, such as mass, electromagnetism, C-field, etc, does not change.

The interesting thing is that, in the present theory, the equations describing gravitation follow, once the action between particles that leads to the property of 'mass' is defined. In general relativity, an extra term has to be introduced and Einstein's resulting equations have then a somewhat ad-hoc character.

The equations of the present theory are more complicated than those of general relativity. They do, however, admit of a simplification in which mass is constant in space and time. The equations then become those of Einstein! The constancy of mass is therefore closely linked with the validity of Einstein's equations. Moreover, because of the similarity of description of mass, electromagnetism and the C-field, there is the hope of a more



Newtonian Theory: Gravitation is a property of matter · any particle (m_1)—attracts any other particle (m_2) by action at a distance, with force—

$$\frac{G\, m_1\, m_2}{d^2}$$

G is determined experimentally (it is 6 67 × 10^{8} c.g.s Units),

General relativity: Gravitation is a property of space-time: particles travel in 'straight' lines in space-time but, as space-time is distorted by the presence of matter, the path appears as a curve in ordinary Euclidean space. Reduces to Newton's theory when the effects are weak G is determined experimentally

The New Theory · Gravitation is a property of the universe, because the mass of a particle, and hence the distortion of space-time it produces, arises from the effect of the rest of the particles in the universe. Reduces to Einstein's theory when mass is constant. G is deduced from the density of matter in the universe.

Fig 3. Theories of gravitation.

complete theory in future which unifies the three. This would be the analogue of a Unified Field Theory linking gravitation and electromagnetism, so much sought after over the last half century; though, of course, this new theory is without fields!

I shall end by noting some points where the present theory differs from general relativity and Newtonian gravitation. In the two earlier theores the sign (i.e. attraction or repulsion) and magnitude of the constant of gravitation G are fixed from local observations—formally, G can be anything. In the present theory, gravitation is inevitably 'attractive' and the value of G follows from a determination of the mean density of matter in the universe, in accordance with the ideas of Mach.

The difference can be best expressed by the following 'thought experiment'. What will happen to the solar system if half the universe is suddenly removed? In Newtonian and Einsteinian theories, nothing. In the present theory, the value of G will go up by a factor two, the Sun will become some hundred times brighter and the Earth will be fried to a crisp!

A more formal point of difference relates to empty space. A number of results of general relativity and of Maxwell's theory

describe interesting situations in empty space. Such situations could not arise in the present theory for the simple reason that it takes two particles (at least) to form an action In other words, there would be no 'physics' if the number of particles in the universe were less than two!

Our Units of Measurement—IV

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IN the concluding article, we propose to discuss the units of measurement employed in the domain of electricity and magnetism. In view of the multiplicity of systems of electrical units that have been in common use, the scope of discussion here is naturally very wide. We shall, however, confine ourselves only to those aspects of the problem which are especially vital for obtaining a view of the whole thing in its proper perspective.

THE C.G.S. SYSTEMS OF ELECTRICAL UNITS

The present story starts with the pioneering work of Gauss (1777-1855) and Weber (1804-1891), which for the first time indicated the possibility of measuring electrical (including magnetic) quantities in terms of the fundamental, mechanical units of length, mass and time, and one additional electrical quantity. In 1863, a British Association Committee, working under the chairmanship of Clerk Maxwell (1831-1879), recommended the adoption of a system of electrical units based on the centimetre, the gramme, the second and the additional quantity, viz., the magnetic permeability of *free* space, which was arbitrarily assigned the numerical value unity. Through a subsequent endorsement of this recommendation, by the International Electrical Congress of 1881, this system acquired the necessary official status for international adoption, and came to be called the *c.g.s. electromagnetic* system of units or else the '*absolute*' system of units. On this system, the unit magnetic pole strength (a theoretical concept not susceptible of physical realisation) corresponds to the experience of a unit force (1 dyne) of repulsion between two identical poles separated by a unit distance (1 cm) in free space. Proceeding from this definition of the unit pole strength and making use of the various derived units of mechanics (the unit of force, the unit of energy, etc.) one can develop a consistent scheme of units, *by definition*, for all the quantities appearing in the domain of electromagnetics.

There was, however, one great disadvantage of the foregoing system, namely, that the magnitudes of the resulting units were not convenient for practical use. The 1881 Congress, therefore, set up a limited number of so-called *practical* units, which were defined as certain appropriate multiples or sub-multiples, in powers of 10, of the 'absolute' units and were named after some of the distinguished workers in the field. These were

1 ampere $= 10^{-1}$ 'absolute' unit of current,

1 coulomb $= 10^{-1}$ 'absolute' unit of charge,

1 volt $= 10^{8}$ 'absolute' units of potential difference,

1 ohm $= 10^{9}$ 'absolute' units of resistance, and

1 farad $= 10^{-9}$ 'absolute' unit of capacity.

In 1889 there followed two more practical units, namely,

1 joule $=10^7$ ergs, and
1 watt $=10^7$ ergs/sec,

while in 1893 was defined the practical unit of inductance.

1 henry $=10^9$ 'absolute' units of inductance.

A second disadvantage of the c.g.s. electromagnetic system of units was that its use in electrostatics appeared somewhat unnatural and artificial. So a parallel system of units came into being, for which the additional quantity to form the fundamental basis was taken to be the electric permittivity of *free* space, with the assigned numerical value unity. This system was designated as the *c g.s. electrostatic* system of units. On this system, the unit electric charge is, by definition, that charge which repels an identical charge situated a unit distance (1 cm) away in free space with a unit force (1 dyne). Again, proceeding from this definition of the unit charge and making use of the various derived units of mechanics, an equally consistent, and complete, scheme of units, *by definition*, can be developed.

In view of the assumption of free space having a unit permeability in the first case and a unit permittivity in the second, the relationships between the corresponding units in the two systems involve certain powers of c, the velocity of light in free space in cm/sec, i.e. approximately 3×10^{10}. For instance,

1 e.m. unit of charge/current $\simeq 3\times10^{10}$ e.s. units of charge/current,

1 e.m. unit of potential difference

$\simeq \frac{1}{3\times10^{10}}$ e.s. unit of potential difference,

1 e.m unit of resistance $\simeq \frac{1}{(3\times10^{10})^2}$ e.s unit of resistance,

1 e.m. unit of capacity $(3\times10^{10})^2$ e.s. units of capacity,

and so on From these relationships one can easily obtain the relevant conversion factors between the e s. units and the practical units.

We note that the two systems of units, viz., the c.g.s. electromagnetic and the c.g.s. electrostatic, can be used either separately or as component parts of the mixed *Gaussian* system Of course, strictly speaking, this scheme does not constitute a basic system of units as such; it is merely an arrangement of using the two basic systems *together*. Here, all those quantities which are predominantly magnetic in character are expressed in the e.m. units while those which are predominantly electrical in character are expresed in the e s. units. The balance in the physical equations is achieved by the insertion therein of appropriate conversion factors, which are invariably certain powers of the fundamental constant c.

THE INTERNATIONAL UNITS AND THE ELECTRICAL STANDARDS

Although electrical quantities can somehow be related to the units of length, mass and time, electrical measurements based upon these relationships—the so-called 'absolute' measurements—are quite cumbersome and time-consuming. On the other hand, measurements involving inter-comparisons of the corresponding electrical quantities are relatively straightforward and capable of much better accuracy. Naturally, therefore, it appeared desirable to establish some sort of international standards of the leading

electrical quantities, so that all subsequent electrical measurements in the laboratory could be made in direct (or indirect) reference to these standards.

With this end in view, the International Conference of Electrical Units and Standards, held in 1908, defined a system of *International Units* which were intended to be as close in value as possible to the 'absolute' practical units defined earlier but based on certain suitably chosen material standards. These were defined as follows:

'The *International Ohm* is the resistance offered to an unvarying current by a column of mercury (at the temperature of melting ice), being 14.4521 g in mass, of constant cross-sectional area, and of length 106 300 cm.'

'The *International Ampere* is the unvarying current which, when passed through a solution of silver nitrate in water (in accordance with standard specifications), deposits silver at the rate of 0.00111800 g/sec.'

However, in view of the practical difficulties encountered in the silver voltameter measurements, the committee also recommended the use of a specified Weston cell as a convenient standard of electric potential difference. The relevant unit defined in terms of this cell, namely the *International Volt,* could in turn be combined with the international unit of resistance to define the corresponding unit of current Even for the resistance standard, it was deemed preferable to employ certain specially designed manganin coils rather than a mercury column

Now, in order to ensure the uniformity of the electrical standards, comparisons on an international scale are clearly necessary. Firstly, this would enable one to record the drifts in values which the standards maintained by the various laboratories show with time. Secondly, one could take the mean of the values for a particular standard, as obtaining in different laboratories, as the Mean International Unit of the corresponding quantity; of course, for the stability of the defined units, the Mean Units could not be allowed to drift much with time.

Such comparisons began in 1910 and continued till 1948 (beyond which there remained no need to go). In the 1910 comparisons, made at Washington, standard resistors and cells from Britain, France and Germany were compared with the corresponding American standards An elaborate series of silver voltameter experiments was also carried out, but the results were found to vary a lot with the type of voltameter used. These results were, of course, helpful as a guide in assigning the numerical values to the e.m.f. of the Weston cells. The mean value of the e.m f. for 104 Weston cells studied was found to be 1.0183 international volts. This value was accordingly assigned to the e m.f. of the Weston Standard Cell

With a view to improving international cooperation the 6th General Conference on Weights and Measures, meeting in 1921, gave its International Bureau at Sevres the duty of establishing standards of the electrical units and comparing these with the national standards. The Bureau accordingly maintained a group of standards originating from the various national laboratories Groups of 'duly standardized' standards were also maintained by a number of leading laboratories of the world. Nevertheless, the periodic

comparisons went to show that the values of the units obtaining in different laboratories continued to have variations of a few parts in 10^{5}!

REVERSION TO THE 'ABSOLUTE' UNITS

As has already been pointed out, the absolute electrical measurements involved a lot of practical complications and demanded a lot of time and effort of the investigator. That indeed was the major reason why resort had to be made to the so-called International Units and Standards. In principle, however, we ought to somehow realize our electrical standards directly in terms of the mechanical units, so that there no longer remains a need of maintaining any material reference standards. It took some few decades before the ground was ripe for this. In fact, as the technique of measuring the 'absolute' units further progressed, a stage was reached, by 1930, when the 'absolute' ohm and ampere could be realized as accurately as their international counterparts. Then, there was left nothing to be gained by retaining the latter.

This was the patent view of the 8th General Conference on Weights and Measures, which met in 1933. They indeed visualised a change-over from the international to the 'absolute' units by about 1940, thus allowing sufficient time for the ratios between the units of the two systems to be accurately determined. This process, however, got considerably delayed by the World War II, and eventually came about only in 1948. Meanwhile certain other developments had taken place which sought for another change-over, namely one from the c.g.s. units of mechanics to the so-called m.k.s. units. The 1946 International Committee on Weights and Measures took momentous decisions, becoming effective from 1st January 1948, which not only incorporated both these changes into a single scheme but also gave rise to a most satisfactory system of electrical units. For a proper appreciation of this transformation, it becomes necessary to re-narrate our story, starting once again from the turn of the century but keeping to a track different from the previous one.

In the wake of the introduction of a number of practical units, during the period 1881-93, there resulted much discussion about the need for an early completion of the practical system, so that the continued use of the mixed (Gaussian) set of units could be avoided. The most fruitful suggestion in this direction came from Professor Giorgi of Rome who, in 1901, proposed a new system of units, which was placed for consideration before the International Electrical Congress of 1904. In this system, the metre replaces the centimetre, the kilogramme replaces the gramme, the second remains as such, while the magnetic permeability μ_0 of free space is chosen to be a dimensional constant with numerical value different from unity. The derived units of energy and power in this system turn out to be just the practical ones, namely the *joule* ($=10^7$ ergs) and the *watt* ($=10^7$ ergs/sec), respectively. The unit of electric current can, using Ampere's law, be defined in terms of (i) the force of interaction between two parallel, infinitely long, current-carrying conductors, (ii) their distance apart, and (iii) the permeability of the medium in between. The relevant formula for the force experienced per unit length of either conductor is

$$F=2\mu\, I_1 I_2/r, \qquad (1)$$

where the symbols have their usual meanings.

Let us now recall that for such a pair of conductors the interaction force, in dynes/cm, for a flow of 1 e.m. unit of current in either of them, with a separation *in vacuo* of 1 cm, is equal to 2 Obviously, then, the interaction force, in newtons/m, for a flow of 1 'absolute' ampere (=1/10 e.m. unit) of current in either of them, with a separation *in vacuo* of 1 m, would be 2×10^{-7}. Thus, the 'absolute' ampere would become the natural unit of current in the Giorgi system provided that we assign a value of 10^{-7} to μ_0. On then follows the natural sequence of units·

(i) the coulomb as the unit of charge, being the amount of electricity transported in 1 sec by a current of 1 ampere;

(ii) the volt as the unit of potential difference, being the difference of electric potential between two points of a conducting wire carrying a current of 1 ampere when the power dissipated between these points is equal to 1 watt;

(iii) the ohm as the unit of electric resistance, defined in terms of the volt and the ampere *or* in terms of the rate of dissipation of heat (in joule/sec or watt) due to the passage of an ampere of current through the resistor;

(iv) the farad as the unit of capacity, defined in terms of the coulomb and the volt, and so on.

The system of units suggested by Giorgi, with $\mu_0=10^{-7}$ (henry/m)*, is thus possessed of the supreme merit of having the 'absolute' practical units as the very natural and fundamental units of the system itself. His suggestions, therefore, deserved a very sympathetic and serious consideration, however, for a period of over thirty years since the suggestions were first made, nothing tangible came out.

It appears worthwhile to point out here that, instead of proceeding on the basis of the Ampere law, one could as well make a start by defining the unit of charge On the basis of the Coulomb law of force between electric charges at rest, namely,

$$\text{Force of interaction} = \frac{q_1 \; q_2}{\epsilon \;\; r^2}, \qquad (2)$$

where ϵ denotes the electric permittivity of the medium concerned. Now, we know that 1 e s. unit of charge experiences, when situated at a distance of 1 cm from an identical charge *in vacuo*, a force of 1 dyne. Obviously, then, 1 'absolute' coulomb (= c/10 e.s. units) of charge would experience, when situated at a distance of 1m from an identical charge *in vacuo*, a force of approx. 9×10^9 newtons. Thus, the 'absolute' coulomb would become the natural unit of electric charge provided that we assign a value of approx. $1/(9\times10^9)$ to ϵ_0, the permittivity of *free* space, one can readily verify that the relevant unit for ϵ_0 would be farad/m*. Indeed, the numerical value of the quantity $1/(\mu_0\,\epsilon_0)^{\frac{1}{2}}$ is approx. 3×10^8, the free-space velocity of light in m/sec.

We thus see that a fully self-consistent scheme of electrical units is obtained by adopting the three m.k.s. units of mechanics, along with a fourth (electrical) unit, such as the ampere (realized by assigning a definite value to μ_0 and making use of the Ampere law) or the

* It may be noted that this value of μ_0 is exactly the equivalent of 1 e.m unit of inductance/cm

coulomb (realized by assigning a definite value to ϵ_0 and making use of the Coulomb law). In terms of the basic set of four units, one can define *quite unambiguously* the whole multitude of units met with in electricity and magnetism. Of course, the simplicity lost in achieving this end is more than obvious from the unwholesome values attributed to the properties μ_0 and ϵ_0 of the free space. One may, however, look at these values simply as certain constants of nature – the so-called '*magnetic* and *electric* space constants'—just as we have the constant of gravitation G. It must be clearly stated that the manner in which the values of these two constants have been treated as adjustable is, speaking from first principles, no more arbitrary than the process of adopting the fundamental units themselves.

Well, it was only in 1935 that the International Electrotechnical Commission resolved to adopt, in principle, the aforementioned Giorgi system of units, and even recommended that this should be the name of the system. However, in a number of countries, it had earlier been called the m.k.s. system, and this terminology has persisted. Of course, a more appropriate designation would be the 'm.k.s.a. system', indicating as well the fourth unit, which was finally chosen to be the ampere, as an *integral* part of the basis for this four-dimensional system.

THE RATIONALIZED UNITS

Having evolved a system of units possessing the desired property of leading, in quite a natural manner, to units which are, by and large, identical with the ones employed in practice, we had to face yet another problem in this field. This problem, commonly known as the 'rationalization' of the system of units employed, is no doubt much less fundamental than that of the evolution of the system itself. Plainly speaking, it doesn't at all constitute a matter of necessity; it is primarily of an aesthetic and/or intuitive origin. It started with the English physicist Oliver Heaviside (1850-1925), who actually waged a life-long battle over it, from the simple observation that in the electromagnetic equations and formulae the factor (4π) appears at rather inappropriate places and it does not appear where it might be expected to. For example, one would expect it to appear in the formulae relating to problems involving spherical (or cylindrical) symmetry, and not in those involving planar symmetry. However, very often the actual situation is the very reverse of this; recall, for instance, the formulae for the capacity of cylindrical and parallel-plate condensers, etc. A situation like this appeared quite *irrational* to any one who looked at things the way Heaviside did.

It was specifically pointed out by Heaviside that the foregoing defect could be remedied by inserting an additional factor of $1/(4\pi)$ on the right-hand side of the Coulomb law. This would restore the factor (4π) to places where it is expected to be and remove it from places where it stands unwanted. Among the typical changes this modification brings about in the formulae of electromagnetics, two major ones are the disappearance of the factor (4π) from Maxwell's equations for the electromagnetic field and also from the statement of Gauss's theorem.

Lorentz (1853-1928), the famous Dutch physicist, was so much impressed by the foregoing proposal that he readily adopted it and, in consequence, chose to modify

the unit of electric charge by a factor of $\sqrt{4\pi}$; this would indeed leave the value of ϵ_0, and hence of μ_0 as well, unchanged. However, one can readily see that if one finds it obligatory to modify the expression for the Coulomb law, as suggested by Heaviside, to

$$\text{Force of interaction} = \frac{q_1 q_2}{4\pi\epsilon r^2}, \qquad \text{(2-a)}$$

it is best to combine the new factor with the permittivity of the medium rather than with the charges involved. For, this way, we would cause a minimum of disturbance in the Giorgi scheme of units. In relevance to (2-a), then, the permittivity ϵ_0 of the free space would be approximately. $10^{-9}/(36\pi)$ farad/m. At the same time, the Ampere law (1) would have to be written as

$$F = \frac{\mu I_1 I_2}{2\pi r}, \qquad \text{(1-a)}$$

with the permeability μ_0 of the free space exactly equal to $4\pi \times 10^{-7}$ henry/m. It may be mentioned here that with this mode of 'rationalization', as the process has come to be called, it is only the units of the magnetic field strength H, the electric displacement D and their derivatives (such as the magnetomotive force, etc.) whose magnitudes get changed by the factor (4π); all the basic units of the system, such as the ampere, the coulomb, the volt, etc. remain unchanged.

Needless to say that, in principle, any system of units, the c.g.s. electromagnetic, the c.g.s. electrostatic, the Gaussian, or the Giorgi, could be had in the rationalized as well as the unrationalized form. It is, however, only in the case of the last one of these that the rationalized form has attracted particular attention.

THE FINAL DECISION

The 1935 resolution of the International Electrotechnical Commission, which sought to adopt the Giorgi system of units, was confirmed by the International Committee on Weights and Measures in 1946. This Committee held that from 1st January 1948 the official system of electrical units should be the so-called 'absolute' system of units, based upon the m.k.s. mechanical units, with a defined permeability of free space as 10^{-7} units. The decision concerning rationalization was, for the time being, kept pending. For a short period, both the rationalized and the unrationalized forms of the Giorgi system were in use, but in 1950 a decision was made in favour of rationalization, the magnetic (free) space constant then being $4\pi \times 10^{-7}$ units* Further, it was resolved that the magnetic space constant is to be realized by way of current, i.e with the help of the modified Ampere law (1-a), holding that 'one ampere is that unvarying current which, when maintained in two parallel, rectilinear, conductors of infinite length and of negligible cross-section and separated by a distance of 1 metre *in vacuo*, would produce between these conductors a force of 2×10^{-7} newton per metre of length.' Of course, in standardising laboratories, the actual equipment with which the 'absolute' unit of current is realized in practice is a precision current balance.

It appears of interest to mention here that at the time of adoption of the 'absolute' electrical units, in supersession to the international ones, the relationships between the two sets were given as under:

1 international ampere = 0 99985 'absolute' ampere,

* It may be mentioned in passing that in this very meeting the unit of force, equalling 10^5 dynes, was designated as the *newton*.

1 international ohm = 1.00049 'absolute' ohm,

whence it follows that

1 international volt = 1.00034 'absolute' volt,

and so on for other related quantities

Thus, we finally have a rationalized system of 'absolute' units, emulating so satisfactorily the set of practical units, which is based on the metre, the kilogramme, the second and the ampere, hence the name 'rationalized m.k.s.a. system of units'. The associated values of the free space constants are

$$\mu_0 = 4\pi 10^{-7} \text{ henry/m,}$$

and

$$\epsilon_0 \sim \frac{10^{-9}}{36\pi} \text{ farad/m.}$$

Since 1950 great strides have been made in adopting the new system of units, with the result that at present it is almost universally employed in the electrical engineering works, and is widely used in textbooks concerned mainly with the domain of electricity and magnetism.

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Casein—The Milk Protein

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PROTEIN is an essential food for all men and animals Without it, no man or animal can build or repair his or its own body. Protein can serve as a source energy for the body. More important is the fact that protein foods furnish building materials for the body proteins, the muscles and tendons, and the skin and hair. Chemically protein is made of simple amino acids.

Milk Proteins

The protein content of cow's milk is about 3.0—3.4 per cent, baffalo's milk 3.4—4.2 per cent, goat's milk 3.7—3 8 per cent and human milk 1.2—1.5 per cent. The proteins of milk of baffalo and goat resemble proteins of cow's milk in respect of amino acid composition. When milk sours or when a small amount of acid is added to milk, a white curd is formed. This white material which can be freed from the whey by means of heat and pressure is called casein. It is the principal protein in most kinds of milk and is widely recognised as a perfect protein. Casein exists in the milk in the form of rather large colloidal particles and forms about 3 per cent of the cow's milk Casein contains considerable quantities of calcium and phosphate. Casein is present in the milk as calcium caseinate, and this gives skim milk its white turbid appearance. Casein is very rich in dietary essential amino acids. The essential amino acids are those that are not synthesized in the body and they must be present in food-stuffs. Other two proteins of milk are lactalbumin and lactoglobulin, which are present to the extent of 0 5 per cent and 0 05 per cent respectively. Because of the ready availability and high nutritive value, casein has assumed more importance in nutrition than other milk proteins. As regards uses other than as food, casein finds a prominent place in different industries.

Commercial Production of Casein

Casein may be separated from milk by different ways. The first method is known as self-sour process Skim milk is allowed to curdle naturally by the fermentation of sugar in the milk to lactic acid which throws out casein from the milk. The curd is easily separated from the whey by slight heating. The curd is washed, drained, squeezed, ground and dried at 50-60°C. In the second method known as acidification method, dilute hydrochloric acid or other acid is added to warmed skim milk to obtain a pH of 4 6-4.8, when the casein is coagulated in the form of a curd. Approximately 0.5 per cent of acidity is required to produce coagulation at room temperature, but about 0 25 per cent may cause coagulation when milk is heated to boiling. The curd is washed repeatedly with acidulated water, drained, pressed, ground

and dried. The third method makes use of rennin, an enzyme capable of coagulating casein from milk. Rennin is a substance that can be extracted from the dried stomaches of suckling calves by a solution of sodium chloride. The solution is marketed under the name of rennet. About 4 ounces of rennet for every 100 gallons of milk are added at 37°C. After incubation for sometime the curd is cut and well stirred, then heated slowly to 50-60°C to hasten the separation of whey. The separated casein is washed, drained, ground and dried. Casein preparations obtained by different methods differ slightly: self-sour casein has better solubility; casein obtained by acidification forms large lumps difficult to wash being consequently of variable quality. Casein prepared by rennet method is most suitable in plastic industry.

Channa is the casein made domestically in India and neighbouring countries from boiling milk by the addition of lemon juice, acid whey or sometimes tartaric acid. The acid coagulates casein and boiling precipitates much of the soluble proteins of the milk. The clot containing the milk fat is separated from the whey by draining and pressing. The product is largely used in cooking and for the preparation of sweets and confectionery. Sometimes *channa* is allowed to ferment and the fermented product gives excellent texture to the sweetmeats made with such product. The *panir* of Afghanistan is made in similar way. In the Sherpa areas of the Himalayas and in Tibet surplus *lassi* (buttermilk) is heated and clot, mainly consisting of casein, together probably with some precipitated soluble proteins, is strained in bamboo baskets; this is either air-dried (churpe) or dried in bamboo baskets under the fire place (churkom).

General Properties of Casein

The commercial casein is a yellowish white powder containing some adsorbed vitamins. Casein keeps well if stored in reasonably dry conditions. Otherwise, putrefaction takes place if it is moist. It is insoluble in water and alcohol but soluble in alkaline solution. Casein undergoes hydrolysis, or decomposition into constituent amino acids in strong and hot acid solutions. The iso-electric point at which casein becomes most insoluble lies at pH 4.6. So casein is commercially separated by bringing its environment close to the iso-electric point of casein. This is generally done by the addition of alcohol, acids or salts, by heating or by the action of rennin.

Nutritive Values of Casein

For maintenance of adult rats, casein is slightly superior to groundnut proteins. For promoting the growth in young rats, casein is of the same order as beef proteins and whole egg proteins, being superior to wheat gluten and groundnut proteins but inferior to egg albumin. For human beings, cooked casein is superior in nutritive value to wheat gluten and ground nut proteins, nearly equal to beef proteins, but distinctly inferior to egg proteins. The biological value and digestibility of raw casein, for human beings, are improved on cooking at low temperature while at high temperature these values are reduced.

Use of Casein as Food and Medicine

In India *channa* is the chief raw material of all sweetmeats. Fried *channa* balls are used in curries and food preparations. The use of casein, either in modified or hydrolysed form, for human consumption is steadily increasing. As caseinate of alkali metals, it is the principal ingredient

of many of the patented and medicinal foods on the market, particularly those prescribed for infants, dyspeptics, diabetics and persons suffering from tuberculosis. In these preparations odourless, tasteless and light-coloured casein is used and its percentage may be as high as 95 In medicines, casein is also used as a vehicle for the administration of iodine, iron, lithium, arsenic, mercury, etc Moreover, casein forms compounds of therapeutic values with salicylates, acrolein, hydrobromic acid and hydriodic acid. Casein is also used as an emulsifying agent for oil for internal administration. Casein hydrolysates of therapeutic values are very common in the market under different trade names. Many preparations of composite protein food from casein have been made Casein is incorporated in bread and biscuits. The caseinated food products are now being used to overcome the protein malnutrition in infants.

Other Uses of Casein

In the U.S.A. and other important milk-producing countries the surplus skim milk, instead of being wasted, is treated to collect casein which, finds various uses in industries In the paper industry casein is used extensively for paper coating where it serves as an adhesive to bind such finishes as china clay, satin white and colouring materials, to the surface of paper in such a manner as to make them an integral part of the paper. Casein is made into glues and pastes and they are used in wood and plywood industries in the making of automobile body frames, pianoes, furniture, doors, refrigerators and general uses where a water resistant glue is desired. Casein glue is specially used for binding linoleum to the running boards of automobiles. For fixing labels to cans and glass containers special casein glue is used. The plastic industries utilize a major bulk of casein to manufacture with formaldehyde a product known as Galaith for use as a substitute for horn, celluloid, bone, ivory, ebony, amber, etc. Made in sheets, tubes and rods this plastic finds various uses in the making of a wide variety of staple and novel goods such as jewellery, beads, combs, buckles, buttons of all shades and colour, cigar and cigarette holders, dice, electrical insulation and switch plates, handles of all kinds, manicure and toilet sets, pen holders, fountain pen barrels, pencils, pipe stems, radio parts, spectacle frames, etc The advantages of casein plastics are many . they are odourless, non-inflammable and cheap, they are easily turned on a lathe, readily sawed, drilled, dyed or glued and take a high polish; they are well adapted to moulding of simple designs. Casein is used as a binder in the making of cold water paint for interior and exterior application. Powdered casein, hydrated lime or other alkalies, pigments and fillers in proper proportions are intimately mixed and soaked with desired quantity of water Casein paint is used for covering canvas, wood, stone, cement, masonry and metals. This paint can withstand rain and weathering. Casein is the raw material for manufacture of casein fibres or casein wool. Casein is dissolved with the help of alkalies, and the solution is forced through tiny openings into a coagulating bath containing materials that harden the fibres.

Bionics

[Bionics is a recent addition to the growing family of science. The young subject has already attracted into its fold a large band of researchers from different disciplines like biology, physiology, physics, chemistry, mathematics, electronics and engineering. Bionics relates to the study of biological mechanism of animals with a view to adapting them in the form of electronic machines. The aim of bionics is to develop machines which can 'see', 'hear', 'smell', or 'sense' a situation and act accordingly. Bionics is a union of biology with electronics. —EDITOR.]

BIONICS, the offspring of biology's mating with electronics, is an additional vast centre of attraction for mathematics, cybernetics, physics and chemistry. Electronics in particular and technology in general must continually find more efficient solutions to their problems. It is the job of bionics to provide them with new devices borrowed from the living world. Far removed from the rigid framework of the traditional sciences, bionics has already led to great many discoveries. We will take a quick glance at some recent borrowings of techniques from the animal world. But the keystone of bionics is beyond doubt the study of the human brain and the possible applications of this study in designing electronic computers.

What is more, the new impetus bionics gives to the life sciences, gives us a better knowledge of man and the living world, dissecting as it does some of the most subtle and the most cunningly hidden life mechanisms. And there are occassions when, as a return, it can enable medicine to improve the operation of a deficient human organ.

Among the devices technology has borrowed from life, we should mention the vibrating gyroscope. The ordinary gyroscope, intended, because of its accuracy, to replace the traditional navigator's compass, consists of a wort of fast spinning top fixed in a frame. No matter what the movements of the ship or the aircraft carrying it, the little whirling disc maintains the same direction, and tells the pilot his course. Now, certain insects have what are apparently vibrating rods behind their wings. These rods fascinated research workers, who learned that they represented a device similar to the gyroscope and, through their inertia, informed the insect of its changes of course. The vibrating gyroscope derived from this, more accurate than the rotating wheel, is now being widely used as an aid to navigation.

The common crayfish in our streams has an accurate organ of balance, sensitive to the slightest vibrations or movements and far superior to our inner ear. Its exact structure has yet to be determined, but this type of mechanism will be very precious in enabling future

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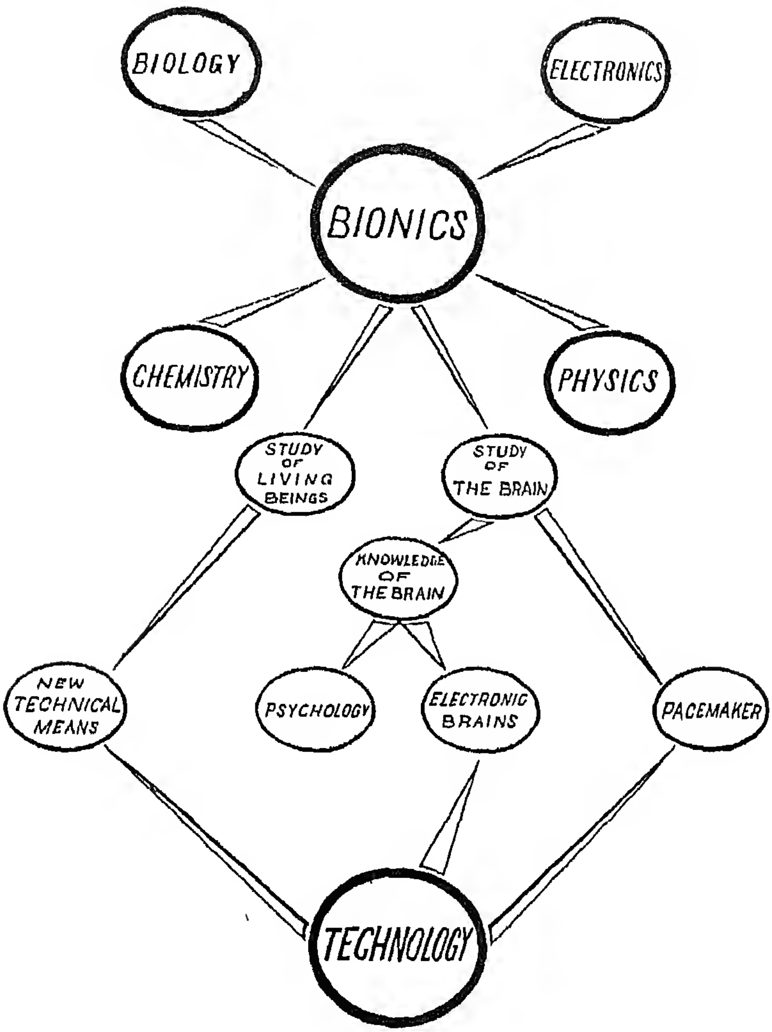

explorers under land and sea to find their bearings.

Another, and different, principle of navigation is a bee's eye, composed of many independent facets. It is sensitive to the polarization of daylight phenomenon our human eyes are incapable of detecting without special optical aids. Thanks to this sensibility, bees can navigate by the sun even when it is completely hidden by clouds or when it is very low on the horizon. Aircraft that operate in the polar regions are nowadays all equipped with a polarized orientation indicator faithfully copied from this compound eye.

We know that radio communication with submerged submarines is very difficult, because ordinary electromagnetic waves are quickly absorbed by water. However, certain fish have a keen sense of small, and are perfectly capable of identifying odours. It is now thought that odours are

caused by the vibrations of the molecules of substances producing them and these vibrations are believed to generate electromagnetic waves. This radiation, when captured by olfactory organs, is then believed to stimulate nerve ends and provoke a corresponding sensation.

In other words, there may be a frequency of waves that is not stopped by water. The study of this phenomenon will perhaps offer a more reliable way of communicating with submerged crews than telepathy, which Americans and Russians are desperately trying to use now. Sometime ago the United States Navy carried out tests on possibility of telepathic communication of a series of five simple signals. Results were deemed to be 'interesting' but offered no hope of fool-proof communication. Obviously, this drawback is a serious one when, for example, someone wants to give the order to lauch a missile polaris. The Russians took these experiments very seriously, and paid close heed to results published in the United States.

There are exotic fish that surround themselves with an electromagnetic field by using nothing less than a generator located near their tails. A dorsal detector enables to feel any variations in this field. In this way they can see a hook behind them, and the slightest movement in any direction is indicated to them. So underwater communication may be possible without using cables, and this may also provide ways of studying submarine zones inaccessible to us.

The bat releases ultra-sounds inaudible to the human ear. These are reflected by objects near at hand, producing echoes that tell the bat where the obstacles are or whether there is prey in its vicinity. Our sonar, the same kind of device, was invented independently of its animal forerunner the similarity being discovered only later But certain moths have sensitive organs that warn them as soon as the beam of ultra-sounds strikes them; the insect knows it has been 'seen' by the bat. Once we have broken down the mechanism of this hidden sense, we may be able to apply it to our own problems.

Even today storms at sea are a nightmare to seamen. Yet animals get an advance warning of this danger. Gulls fly around excitedly, dolphins take shelter near rocks, whales head out to sea, and jellyfish drop down into deep water. They can sense this danger by listening to the noise of the storm in ultra-sounds whose frequency is beyond our ears. An artificial 'ear' that picks up these sounds perfectly has been constructed by biophysicists at the University of Moscow. This device gives a fifteen-hour warning of a blow, supplying its direction and even its strength.

A good many other examples might be mentioned. We certainly should not overlook the rattlesnake, which can detect temperature changes of one-thousandth of a degree centigrade. But generally speaking, it is now certain that the systematic study of these ingenious natural solutions, overlooked or misunderstood for a long time, will provide thousands of applications in solving human problems

But the path along which bionics is developing most rapidly of all is the study of the human brain, the natural model for the development of electronic computers. At the present stage of their evolution, these computers have reached a crucial point, where their growing complexity creates the need for such a model.

HOW THE HUMAN BRAIN WORKS FOR ELECTRONICS

In recent years electronic brains have developed extremely rapidly. A dozen years ago, before transistors, electronics was still at the vacuum-tube stage. No one could envisage an electronic brain comparable to the human one. Indeed, such a machine would have required all the power of Niagara Falls to function—and all the water in the falls to cool its circuits.

Since then, progress in electronics has divided the size, power requirements and heat radiation of such a machine by one thousand. We are still a long way from the efficiency and compactness of the human brain-pan, but research is making headway Increasing knowledge of living nervous systems and of the way in which information is perceived, learned, classified, compared, and retained, will permit the construction of better-organized electronic brains.

Mathematicians and specialists in system analysis are being guided in this by the biologists. Chemists, physicists and electronic engineers offer computer builders' new materials that correspond to the flexibility in operation of living systems. This is why a symposium held at Dayton, Ohio, where the term 'bionics' was invented, embraced subjects ranging from the properties of neurons to the entirely self-programming computers of the futures

Machines are now being constructed that will play the role of the eye-brain team in man. At Princeton there is a device that can 'see' and recognize the size and shape of objects. It can also detect changes in an image with mobile components. The electronic brain interprets what it learns from a series of photoelectric cells.

The final stage would be the equivalent of the living eye with all of its functions, capable of deciphering and interpreting all images, whether printed, drawn, or received on a radar or television screen. In the same way, electronic 'ears' are being studied so that artificial minds can interpret verbal instructions

The complexity of machines rivalling the brain even in a few clearly defined and specialized functions is almost impossible to imagine. Such devices will have to contain hundreds, even thousands of millions of parts. Our success depends upon our ability to produce these parts cheaply, accurately and in the smallest possible size The cross roads of low temperatures will give us a glimpse of the opportunities offered by superconductors.

Meanwhile, using moletronics and thin-film techniques, we can construct miniaturized circuits so small that twenty thousand different parts—each of them doing the work of an ordinary radio tube—could be placed on a postage stamp. It is this extreme compactness that allows us to foresee decisive progress but, at the same time, it does raise the problem of the best possible organization of various circuits Here, the study of the connections and relationship between parts of the brain can help scientists. The study of a nerve cell—the neuron—can inspire them with ways of connecting and conceiving a multipurpose switching unit.

The first goal is the creation of self-programming machines capable of organizing their work themselves. Forerunners of such devices—still very rudimentary—do exist already. For example, RCA's

transatlantic radio service is handled over parallel channels which are used alternately, depending upon their load and atmospheric conditions. A machine chooses the path to be taken by each message, and no one can say in advance which route will be adopted.

Before we can attempt much more complex machines we shall have to make great advances in good many fields, particularly in the development of new mathematical methods. But above all bionics must increase our knowledge of the brain and of the inner mechanisms of thought. On the one hand, we expect it to provide information on the layout of future computers; and on the other, our knowledge of ourselves and of our functioning as conscious beings is making steady progress. In this way bionics establishes a two-way current of information and research, stimulating both the life sciences and technology.

Its applications are occasionally spectacular and relatively easy. For example, scientists learned how muscles are stimulated by impulses moving along nerve fibres, and discovered the nature of these impulses. From this it was a short step to the transistorized artificial pacemaker that can govern the beating of the human heart in an emergency.

Still the main object of these studies is the brain itself. But remember that our knowledge of it is still very rudimentary and superficial. Years will go by before we can hope to understand the intimate mechanism of thought, memory, and the co-ordination of a human being's functions. But the work has definitely begun, and is extremely important.

At the University of Goteborg in Sweden, a team led by Professor Holger Hyden is working on the neuron—the basic cell of the nervous system. The brain has about ten thousand million of them, each a chemical factory in miniature participating in a number of mental processes, often simultaneously. Compared to this complexity contained in such a small space and working with such incomparable efficiency, our electronic brains are still very clumsy. This does not prevent certain scientists from working backwards and considering the human brain as a highly perfected computer, a vast series of circuits and switches.

EXPLAINING THE WEALTH OF HUMAN THOUGHT

It must be stressed that we are now only at the speculative stage, and research workers must be given free rein. Their tools are now on the scale of the phenomena under study. Literally to attempt to weigh thoughts, we must be able to measure accurately millionths of a millionth of a gram. By such methods, Hyden determined the way neurons transmit nerve impulses. The study of the electric nature of these impulses was fairly well advanced, but little was known about what went on inside the nerve cell. Hyden managed to detect some of these obscure processes.

In the neuron the passing of an impulse is translated into extremely rapid electro-chemical reactions. At the time of stimulation, the amount of certain proteins—their nature varies according to the message—suddenly increases in the cell. The molecules of this particular protein are a material expression of the impulse that the neuron sends to its neighbours. The rapidity of the appearance of these specific substances is explained by the

existence around the neuron of small satellite cells that give the neuron the substances it needs. Thus it does not lose any time synthesizing them. Impulses can thus be transmitted along a chain of neurons at the rate of 130 feet a second. According to Hyden the brain's higher functions, such as memory and thought, are explained by the appearance of proteins corresponding to each stimulus

Each neuron can synthesize a number of different proteins When an impulse reaches the brain—when the eye sees a green light, for example—all the neurons that can produce the protein corresponding to this signal are alerted and begin to secrete it. The presence in the brain of this protein makes us realize we are seeing this particular shade of green, makes us remember having seen it already. Each of the brain's many neurons can secrete millions of different proteins. This leads to an astronomical number of combinations which would explain the wealth of human thought. This might also be the reason why it has never been possible to assign any of the higher cerebral functions to clearly-defined areas of the brain

When you follow this Swedish research to its logical conclusion, then consciousness, morality, and all that man does, become a matter of molecules These ideas were already suggested decades ago, but only now has science progressed to the point where the brain's activities can be tested experimentally We shall have to wait patiently until this research is sufficiently advanced. Meanwhile, bionics will have enabled the rational organization of electronic brains to perform complex tasks. It will not be at all startling if, in a short while, meteorology, for example, is turned over to computers Then man, free of such laborious tasks, will be able to do more creative work

The Unborn One

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I HAVE seen hundreds of eggs, yet never have I been able to look through the shell and perceive the wonder within, never have I been able to appreciate the extra-ordinary genius of Nature hidden inside the wonderful egg. How does young chick, full of life, emerge from an egg, which to all appearance, was a mere bit of sticky yolk? I could only find out by examining eggs of various ages

The purpose of this project was to study the chick's development while still in the egg. I knew that that there was something that happened in the egg when a hen sat on it, and perhaps that is how a chick is formed from the egg.

MATERIAL AND METHODS

Not much of equipment was needed. A few shallow vessels, a pair of fine scissors, forceps, a needle mounted on a handle, a blunt tongue-depresser, a medicine dropper, a few jam jars, 4 per cent solution of formaldehyde, and normal solution of 0.75 per cent saline were all that I needed. A few rings of different sizes cut out from filter papers, and a hand lens were my additional requirements.

I had an old box camera which had ceased to be of service and which I did not throw away. I had always thought that if nothing else, the springs or the metal pieces could come in handy sometime or the other. When a microscope was needed for more detailed examinations of specimens, I took off all the lenses and reassembled them in a cardboard tube using candle wax to fix them properly. With my textbook knowledge of optical instruments, I managed to improvise a working microscope which could enlarge objects nearly 50 times

For my project, at least a dozen eggs of known ages were needed. Artificial hatching was necessary. Knowing the requisites of an artificial hatching device, I proceeded to model an incubator.

An old wooden box was taken. To this was fixed a night bulb and a lid. Three holes of half-inch diameter were made on the top; one on the right hand corner, one on the left hand corner, and a third in the middle. I lined the inside of the box with cotton-wool (for insulation) and plugged the two corner holes with cotton. A centigrade thermometer fitted into the third hole told me the temperature of the inside. This was not enough. The humidity had to be maintained at 50 to 70 per cent. A coffee-can

Sri Ram is a member of Bal Bhavan and National Children's Museum New Delhi This article is published as an example of a project that a student could do either at home or in the school.

filled with water and a small piece of mud-pot kept partly dipping in the water helped to maintain the proper level of humidity. I refilled the water in the coffee-can whenever it dried up.

All that I had to do to set the incubator working was to close the door of the incubator and switch on the bulb and after every two hours or so, read the temperature from the thermometer. By judiciously opening the two corner holes on the top, I maintained the required temperature between 30°–40°C.

EXPERIMENT AND OBSERVATION

I next bought a dozen hen's eggs from a dairy, and marked on them with a pencil, the date of purchase, and placed them in the incubator. All set, I launched on my project. Here are my observations in brief.

On June 18, I opened a fresh egg and studied the internal structure. An oval ball of yellow yolk in the centre was separated from the surrounding colourless, jelly-like albumen. On either side of the yolk, reaching up to the end of the egg was a twisted chord, the *chalaza* (Fig. 1).

The egg was protected by a thick shell. Between the shell and the contents of the egg were two thin membranes. At the broader end of the egg, the two membranes separated out to enclose a little air between them. On the dorsal side of the yolk was a white speck, the *blastodisc,* placed directly in the centre.

After waiting for a day, I opened another egg. I held the egg in my palm so that it rested on its larger side. I then poked carefully a needle on the side of the egg, about half an inch from the top Then I inserted a pair of scissors into the hole and cut round the egg. Having done this I lifted, with forceps, the top, as if it were a lid.

To my disappointment I found that there was no development in the egg. I had misgivings about the effectiveness of my incubator. Then someone told me that when the cocks are not sufficient in number to mate all the hens in the poultry, there are chances of some eggs being unfertilized. This was news to me, for I had presumed that all eggs could produce chicks. Now I understand that the male unit of reproduction (*sperm*) that is required to fertilize the egg does not enter all the eggs and hence the existence of unfertilized ones One thing I noticed was that the *blastodisc* was always on the dorsal side, no matter in which position I held the egg. I held one of the eggs in a certain position, and then turned it upside down and cut it open quickly, and found that the yolk was slowly turning sideways so that once again the *blastodisc* came up to the dorsal side of the yolk. So there must be some factor that makes the blastodisc always incline towards the dorsal side.

The next few days found me going from place to place in search of fertile eggs, until by chance I came across a poultry farm where fertile eggs were being sold. The man assured me that at least 80 per cent of the eggs would be fertile. I bought a dozen of these eggs and placed them in the incubator with fresh hopes.

My persistence did not go unrewarded, for after a day of incubation I opened an egg and found, to my joy something

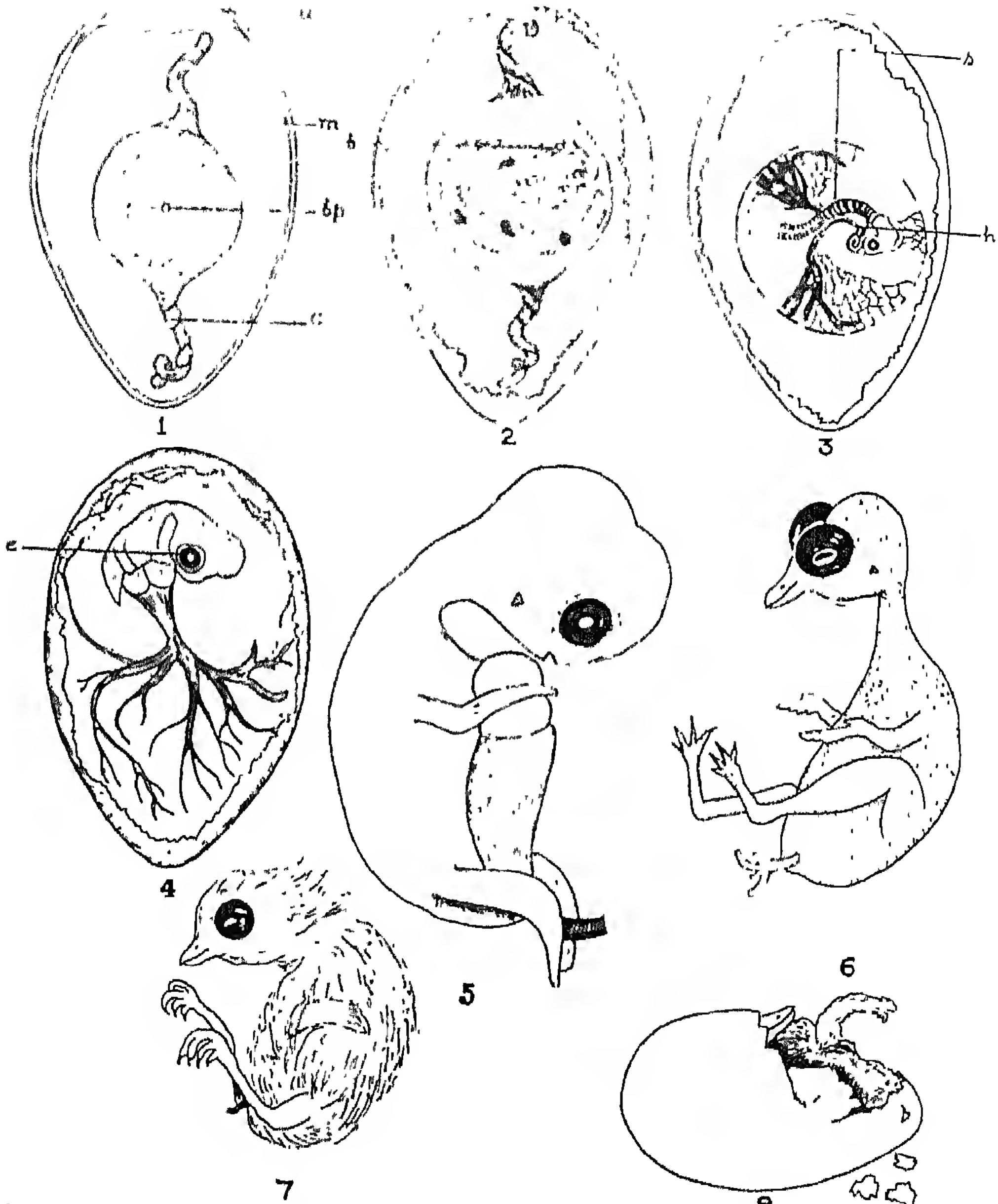


Fig 1. The structure of an egg: embryo a mere speck. Fig. 2. The 1-day embryo. a tiny rod. Fig 3. The 2-day embryo: heart appears. Fig 4. The 5-day embryo: limbs are seen C. Chalaza a=airsac; b=blood island; d=blastodisc; e=eye; h=heart; m=shell membranes; s=somite. Fig. 5. The 8-day embryo: the ear is visible. Fig. 6. The 10-day embryo· the heart is pushed into the body. Fig. 7. The 12-day embryo: developed, but pre-mature. Fig 8. Hatching· birth at last.

more than what I had seen in a fresh egg. In place of the *blastodisc*, a more or less discoid area clearly differentiated from the remaining yolk surface was seen At the periphery of this area were a number of spots which perhaps had something to do with blood Within this area was a membrane less opaque than the outer area This membrane bore a thin stick-like structure with a knob in front. On closer examination I found that that was the embryo which later would develop into the chick. This had a minute hole at the tip of the head. Right down the middle of the embryo ran a thin groove Farther down, on either side of the groove were six paired blocks which made the groove look like the spinal cord, while the blocks themselves looked like vertebrae in section (Fig. 2).

The next day I examined an embryo that had been incubated for two days. The embryo that had during the first day of development been lying on its back, now lay on its side. The chalaza was absent. The embryo had the shape of a question mark I realised the existence of a small bag which became red and pale-pink alternately. This was engulfed in the anterior area. I recognised this as the heart. I traced a number of blood vessels through which the blood, fresh and wine-red in colour was flowing in spurts. This was not so readily visible to the naked eye, but my improvised microscope enabled me to see the spurting movement of blood. These blood vessels spread in all directions along the membrane surrounding the yolk. Why does an embryo, as yet only two days old, need blood circulation? What does the embryo feed on, to grow? Where is the mouth for eating? And then why are the blood vessels outside the body instead of being within it?

Finally I understood, the embryo 'feeds' on the yolk particles Since its mouth is undeveloped, the embryo 'eats' by another well contrived device. It pumps blood to the yolk membranes The blood, while passing through the yolk, takes up a number of yolk particles and carries them back to the heart This yolk-laden blood is then circulated within the embryo The embryo thus has two types of circulation at this stage—the embryonic circulation and the extra-embryonic circulation

This stage of the embryo had 23 of those paired blocks, or *somites* A few drops of saline produced movement of the embryo To preserve this embryo, I took a filter paper ring, a bit smaller than the *embryonic disc* (area where the embryo and blood vessels lie). Placing the ring on the embryonic disc, I cut around the filter paper. I then lifted the embryo along with the paper ring, using forceps, and placed the embryo in a petri-dish containing normal saline, solution.

After the adhering yolk particles had been washed off, I carefully transferred the embryo to a petri-dish containing a 4 per cent solution of formaldehyde.

I was surprised at the appearance of limbs in an embryo which had developed for five days. The embryo was enclosed in a sac containing some fluid (Fig. 4). The unborn chick had a pair of forelimbs, slightly bigger than the hind limbs which, unlike the forelimbs, ended in conical structures.

The heart was divided into two chambers. Each pumped blood alter-

nately. The heart ended in a tapering structure which branched off as blood vessels.

A few drops of saline made the embryo shrug. The poor creature seemed to cling desperately to its heart with its weak limbs.

After this, I turned the eggs upside down daily. (I do not know the purpose, but someone told me to do so.

I have never had nor will have the opportunity to experience what a mother feels when she sees her child play and grow every day. But this project provided a near substitute, for everyday found me watching intently the growth of the 'chick' with increasing joy.

After eight days of development an embryo is a real thrill of joy to see. The big outsized brain, the disproportionately huge eyes protruding out of the head, the small opening between the two eyes that later becomes the mouth, the two small triangular openings for hearing, the huge heart which completely covers the front part of the body, the four big folded limbs; all this on a small curved body—this is the splendid sight that an 8-day embryo affords (Fig. 5).

A beak on an embryo that does not in any way resemble either a bird or a chick is very odd. All embryos younger than the 10-day embryo had their eyeballs attached superficially, but in the 10-day embryo, the eyeballs were buried and covered by the surrounding skin. All along, the heart had been outside the body but in the 10-day embryo, all but the big blood vessels arising as a continuation of the tapering portion had been pushed into the body. The limbs were bigger, and forked. The skin was covered with small dots which looked more or less like buds (Fig. 6). I stored all these embryos in bottles containing 4 per cent solution of formaldehyde and labelled them according to age.

A twelve-day embryo is in all respects similar to a fully grown chick; only, it is smaller. The whole body is covered with silky hairs, the hind limbs end in four well-developed toes and the forelimbs look like wings (Fig. 8). When I opened a 12-day old egg, I found the eyelids of the embryo slightly open.

Taking an incubated egg, 20 days old, I carefully peeled off the shell without injuring the interior. To my surprise, I found something poking out of the membranes covering the embryo. I felt it with my fingers and the thing moved: I could hear a squeaking sound. So that was the beak; it had pierced through the membranes for drawing air from the air sac. I tore away the membranes and found a chick, developed in all respects. It really was a wonder to find such a huge chick enclosed in a shell so small as that.

Two more eggs remained, and they were nearing their hatching hour? My calculations told me that the struggle for freedom would start sometime at midnight. Making a safe guess, I fixed my alarm clock to ring at 2 O'clock. The ringing of the bell at 2 O'clock next morning roused the whole family. I went to the incubator and to my disappointment, found no signs of birth. Then suddenly, I heard a low knocking sound quite distinct and regular. I picked up that egg from which the sound came. (Eventually I was to discover that the other one was unfertilized.)

So at last my chick was striving to come

out of the shell. I carefully lifted the egg and placed it on a cotton spread.

The struggle started. The chick pecked at the hard shell. After a few minutes' rest it attempted again, and again, until finally it succeeded in making a crack on the shell, then a small hole. It pushed out its beak through the hole and started sawing with the hard sides of its beak. The hole grew larger and the energetic bird worked on unceasingly. It had lived on nothing but a small mass of yolk for the past twenty-one days; yet the energy and unfailing determination that it possessed was remarkable. 'What gives it such motive force ?' I wondered.

Finally the forelimb of the chick emerged The beak moved behind the shell once again so that it became out of sight. The beak pecked from one side and the forelimb fluttered from the other until the shell gave way (Fig. 8). This went on until nearly half the shell was chipped off

It was 07.09 hours. The chick was relieved of all bondage. *My chick was born.*

Like a hen, I had, for the past twenty-one days, meticulously incubated the eggs, and here was my reward—my sweet young one.

Abhesives

Padma Vasudevan
Madras

ALL of us know about adhesives. Adhesives are those substances which stick easily. Nowadays many substances have been discovered which have the property of not sticking. A new word has been coined to describe them. They are called 'abhesives'. What can abhesives be used for? Many practical uses have been found for them and are being suggested.

Since they repel water they are used for water proofing clothing, tents and boats. For example dip and dry fabrics coated with abhesives dry very quickly. Similarly basement walls can be made waterproof by giving a coating of abhesives.

In the home, frying pans and baking pans coated with heat resistant abhesives like silicones and fluoro-carbons like Teflon, are used. Unlike ordinary grease they do not char or smoke and can be used for a longer time. For example silicone-coated pans can be used for about 200 bakings. This eliminates repeated degreasing and greasing. Also since things fried or baked do not stick to the pan coated with abhesives, eggs, meat, cheese, etc., can be fried with very little fat and can be removed easily from the pan.

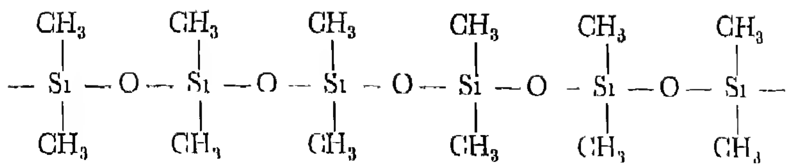
Abhesives like Teflon and silicones are excellent lubricants which can stand high temperatures. For example one of the silicones remains as a smooth white jelly from 40°F to 400°. Besides, they are non-conductors of electricity. Hence they are used as lubricants in sealed electric motors of household appliances like washing machines, vacuum cleaners, refrigerators, etc., and as bushings, ball-bearings and joints. In fact it is hoped that by using abhesives the problem of lubrication of machines from time to time can be completely eliminated.

Abhesives as lubricants, are of great importance in many industries. For example in the manufacture of tyres the difficulty of rubber sticking to the moulds has been overcome by coating the moulds with abhesives.

Electric irons, the bases of which are coated with abhesives move much more easily on cloth. Furniture and automobile waxes and polishes containing abhesives prevent water, dirt, etc., from sticking to the surface.

Since many of the abhesives are not physiologically active they are used in surgery. Teflon tubings have been used to replace artery sections.

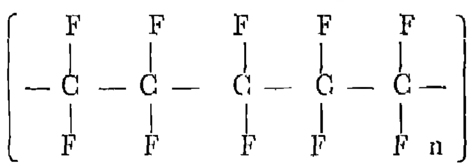
Why do abhesives have little attraction for other surfaces? The answer becomes clear from a study of their structure. Taking the example of silicones and fluoro-carbons we find both are long chain polymers with atoms or groups of atoms packed regularly around the central chain.



For example, silicones have a silicone-oxygen chain with organic radicals like methyl groups attached to the silicon atoms.

In such polymers there are two types of valence forces, the primary valence forces existing between the atoms actually in bondage and the secondary valence forces resulting from the attraction between neighbouring atoms or radicals. It is the secondary valence forces which determine the physical properties of these polymers. Actually their physical properties can be changed by changing the length of the polymer or the kind of the organic radicals attached to silicon atoms. These attached radicals form a close shell around the main chain leaving very little attraction for molecules on other surfaces.

The same is the case with fluoro-carbons also. For example Teflon which is poly-tetra-fluoro-ethylene has fluorine atoms bound tightly around carbon atoms. In this case since fluorine atoms are large and so near one another, a third, steric factor also promotes abhesive properties.



Teflon or polytetrafluoro ethylene

The question automatically arises as to how a coating of a material with abhesive properties can be given Various methods of coating are employed depending on the material being coated and the nature of the abhesive used for coating.

Usually the abhesive is dissolved in a suitable solvent or emulsified with water. If the material to be coated is a fabric or any porous substance it is impregnated with these solutions by dipping. Alternatively the solution may be sprayed or applied as a thin coating by wiping or brushing. Then to make the coating set firmly on the article, it is 'cured' by slowly raising the temperature. In this process the solvent is slowly evaporated and cross links are formed between the polymer molecules. Since the polymer molecules have very little attraction for each other, usually curing agents are added. The polymer molecules are united chemically through these curing agents. There are other methods also like baking the abhesives on glass with addends like graphite. As mentioned earlier different methods are employed for coating different substances.

It is obvious from these considerations that abhesives have a great future in the betterment of life.

General Science Curriculum for Higher Secondary Classes—III

Department of Science Education, National Council of Educational Research and Training, New Delhi

[The earlier parts of this series appeared in the previous issues of this journal. The sequence of major and minor concepts is concluded with this article.* EDITOR]

VII. CHEMISTRY IN DAILY LIFE

G. *Photography is the chemical process of the formation of an image on the photographic plate.*

The subconcepts 1–5 have appeared in the last issue.

6. The unchanged silver bromide is removed by immersing in 'hypo' (a solution of sodium thiosulphate). This is called 'fixing'. The black inverted picture formed is called the 'negative'.

7. The positive print is made by superimposing the negative on a sensitized paper and exposing it to light for a suitable length of time and then developing and fixing the print as in the case of the negative.

8. Many advances have been made in photography: coloured photography, transparencies, motion pictures, aerial photography, high speed photography.

H. *Fertilizers*

1. Plants require nitrogenous compounds and phosphates soluble in water for their growth.

2. The conversion of atmospheric nitrogen into useful compounds is called fixation of nitrogen.

3. Nitrogen fixing bacteria in soil or in the roots of leguminous plants do this in nature from atmospheric nitrogen.

4. Nitrogen is also fixed in several other ways.

   (a) Lightning converts nitrogen and oxygen into nitric oxide which in turn is finally converted to nitric acid and nitrates.

   (b) In the Birkland Eyde process nitrogen and oxygen are converted to nitric acid

   (c) In the Haber's process nitrogen from air and hydrogen are combined to form ammonia which may be converted to ammonium salts or oxidized to nitric acid.

   (d) In the Cyanamide process calcium carbide and nitrogen

*General Science Curriculum for Higher Secondry Classes. SCHOOL SCIENCE, 3: 151–155, 246–254 June and September 1964.

from atmosphere are converted in an electric furnace into calcium cyanamide which can be readily converted into ammonia or nitric acid.

(c) Most of the plant fertilizers are used in the form of ammonium sulphate, ammonium phosphate, potassium nitrate, calcium nitrate, and urea.

5. Another element needed by plants is phosphorus. It is usually supplied in the form of calcium phosphate, superphosphate or ammonium phosphate

6. Calcium phosphate is obtained from the bones of animals or rock phosphates

7. Artificially, superphosphates are manufactured from rock phosphates.

8. Care should be taken in the use of fertilizers (they have some ill effects).

VIII LIFE

Ultrastructures

A *Studies of sub-cellular organization are made in order to explain the relation between structure and function in terms of organization and interaction of macro-molecules. This area is called molecular biology*

1. (i) Electron microscope has helped biologists to study the ultrastructures.

(ii) Some of the submicroscopic structures are mitochondria, grana, endoplasmic reticulum and ribosomes.

B. *Mitochondria are microscopic powerhouses and the site of cellular respiration*

1. Mitochondria have a highly complex and differentiated internal structure.

2. The behaviour of mitochondria is correlated with intra-cellular activity

C. *The chloroplasts are characterized by the presence of bodies called grana embedded in a uniform stroma*

1. Each grana shows a complex structure with a number of membrane elements stacked one on top of the other

D *The endoplasmic reticulum is an internal transport system.*

1. The outer surface of the endoplasmic reticulum is associated with ribosomes which are rich in RNA.

2. These are the sites of protein synthesis

Viruses

A. *A virus is essentially a nucleoprotein particle which seems to occupy a place midway between the inert chemical molecule and the living organism*

1. Iwanowski found that the filtered juice of an infected tobacco plant could transmit the disease to a healthy plant.

2. Stanley (1935) separated tobacco mosaic virus (TMV) from the host in a crystallized form. This shows that viruses are not living organisms.

3. Virus particles are submicroscopic and are visible only with the aid of an electron microscope.

B. *Viruses do not have any of the recognizable structures of a cell*

1. Each virus particle has a nucleic acid core and a protein shell.

C. *Viruses are obligate parasites capable of multiplying only inside the living cells of the host tissue.*

1. Viruses cannot be grown in cultures outside the living tissue.
2. Outside the living cell the virus particles are inert and lack metabolism and reproduction.
3. Viruses retain their ability to infect even after long isolation from living material.
4. Among the properties of living organisms shown by viruses are their power of replication in the host cells and the ability to mutate.

D. *Viruses cause major diseases of plants and animals and man.*

1. Some of the plant viruses are tobacco mosaic virus, the curly top and serah disease of sugarcane.
2. One of the animal viruses is the foot and mouth disease.
3. Some of the virus diseases of man are smallpox, poliomyeletis, mumps, common cold, Asiatic flu, etc.
4. Some viruses do not cause disease. They are used for horticultural purpose, as in the breaking of the tulip.
5. Viruses are used to fight pests (rabbits and insects).

E. *Certain species of bacteria are attacked by virus. These are called bacteriophages.*

F. *Virus diseases can be transmitted by various ways.*

1. By contact.
2. Through injuries.
3. By vectors.
4. By coughing and sneezing of animals.

G. *Some viruses require a period of incubation before they show symptoms.*

1. Quarantine measures are adopted as preventive steps to the spread of virus diseases.

H. *Viruses help us in our understanding of the lowest level of life. They seem to stand at the very threshold of life.*

1. Viruses are placed a little above the level of complex molecules like those of nucleic acid which have the capacity of replication.
2. Viruses may be placed just below the level of cellular organization. They have none of the enzymes found in the cells.

Origin of Life

A. *Living creatures on earth are the direct products of the earth.*

1. An earlier belief that life arose by spontaneous generation was disproved by Redi, Spallanzani and Pasteur.

B. *The modern view is that living things arose at first spontaneously from organic compounds reacting with each other.*

1. Stanley Miller conducted an experiment under conditions resembling those on the primitive earth and obtained organic compounds–amino acids.

C. *The compounds reacted with each other to produce sugar, amino acids, proteins, nucleic acids and nucleoproteins.*

D. *Some of the proteins acquired enzymatic activity.*

E. *The next stage was critical. It was the formation of an organic molecule (DNA) having the property of self-duplication.*

F. *By the aggregation of other molecules round the self-duplicating molecule the primitive cell was organised*

Genetics

A *The field of biology which treats of heredity and variation is called genetics*

1. Like begets like.
2. Heredity is the transmission of characters of the parent to the offspring.
3. The tendences of organisms to differ from their parents is called variation These may be due to
   (a) environmental conditions
   (b) hybridization.
   (c) mutation.

B. *Mendel found out that inherited characters are transmitted according to certain laws.*

1. The sex cells are the physical bridge between the parent and the offspring. Hence any factor developing into a character must be passed on through that cell.
2. When individuals differing in two contrasting characters were crossed the hybrid showed one character (dominant), while the other was hidden (recessive). This is the law of dominance.
3. When the hybrids were crossed among themselves the two characters showed up in a ratio of 3 .1. The apparently lost trait (recessive) reappears in the offspring of the hybrid. This separation is known as the law of segregation.
4. The factors, representing the two or more contrasting characters are segregated independently of each other. This was described as law of independent assortment.

C *There are convincing evidences to support the view that hereditary determiners are carried by the chromosomes in the cells*

1. The behaviour of genes in breeding experiments and the behaviour of chromosomes during nuclear division are parallel.
2. Genes that lie on the same chromosome tend to remain together and the characters are thus linked.
3. Some times such linked genes separate due to crossover Sex is inherited and it follows a given distribution of the chromosomes according to definite Mendelian ratio.

   The sexchromosome may carry a number of genes for a number of characters Such characters are sex-linked characters.

D *It has now been found that DNA (deoxyribonucleic acid) is the principal constituent of chromosomes and this is the chemical basis of inheritance.*

1. The molecules of DNA are large The mode of construction of its constituents (nucleotides) enables them to contain an enormous amount of 'coded' information and to undergo replication (i.e., exact duplication in every respect).

E. *Heredity supplies the native capacities of an organism, environment determines to a large extent how full these capacities will be developed.*

1. In inheritance the final product is

the result of heredity and the environmental factors.

F. *Knowledge of heredity is important in many phases of modern life.*

1. It helps in the production of new varieties of garden plants, crop plants and fruit trees and useful animals.

Organic Evolution

A. *Organic evolution is the gradual change in living organisms from the simple to the complex, over a long period of time and due to the operation of natural forces.*

1. All life comes from preceding life.
2. Industrial melanism is an instance of an evolution within a short time and which is observable.

B. *Evidence for organic evolution can be drawn from various sources.*

1. The biological time-scale reveals fossils of simple forms in oldest rocks and those of the complex in the upper rocks.
2. The evolution of a particular type like the horse is indicated by the study of the fossils of the horses of different ages.
3. Evidence from structures, development and geographical distribution are other great supports. Charles Darwin collected a mass of evidence from his voyage on *H.M.S. Beagle*.
4. Domestication and hybridization also yield evidence for the evolution theory.

C. *Several theories have been put forward to explain the phenomenon of evolution.*

1. Lamarck believed in the theory of inheritance of acquired characters.
2. Darwin and Wallace proposed a theory of the origin of species by means of natural selection.
3. According to deVries, mutation and not selection should be considered as the primary factor in evolution.
4. Modern theories accept generally the fact that evolution is directed by natural selection.

D. *Evolution by natural selection results in the survival of favourable variants in relation to the environment.*

1. Variation and heredity shown by the members of a species are together responsible for the continuation of the process of evolution.

E. *Adaptive responses to different environmental factors bring about differences between related groups.*

1. Protective adaptations aid survival.
2. Isolation due to geographical barriers or genetic differences bring about evolution along different lines.

F. *Natural selection gives direction to evolution by selecting the favourable variants to have more progeny. Eventually these form the whole population.*

1. Population is the unit of evolution, the genes within the population are called the gene pool of the population.
2. The population is in equilibrium after a period of interbreeding.
3. Reproduction heredity and variation are the chief characters of life enabling population to change

and adapt to the environment under the operation of natural selection

Hybridization

A. *For centuries man has made a constant effort to improve the varieties of plants and animals which supply his needs By means of hybridization entirely different kinds of plants and animals have been developed*

1. Crossing of two different varieties to obtain a new one is hybridization or outbreeding.
2. Inbreading or line-breeding results in a pure strain.
3. New plants are produced by crossing different varieties and even species.

B. *One of the advantages of hybridization is hybrid vigour in the offspring. Often the new hybrid has a natural vigour which neither parent had.*

1. The hybrid corn is the result of a double cross in which four pure-line parents are mixed in two crosses.

C. *Selective breeding methods have been used to develop desirable varieties of plants, poultry and livestock.*

1. Some of the desirable qualities in plants are disease resistance, larger yield, hardiness, etc.
2. In animals too the desirable qualities are disease resistance, hardiness, greater yield of milk or mutton.

D. *A true hybrid is the offspring of a cross between two different species.*

1. The mule is an example. With all its vigour the mule is sterile.

E. *Hybridization gives variation, isolation gives fixation, and fixation gives speciation. This is how hybridization helps evolution*

1. New types of organisms different enough to be regarded as new species may result from a cross.
2. In nature also hybridization takes place between close varieties

F. *Many chemical compounds are used to destroy or control the activity of pests*

1. Chemical compounds used to destroy or control the activity of pests are called insecticides.
2. Insecticides may act as stomach poison or as contact poisons or as poisonous gases that penetrate the insect's body
3. Insecticides of inorganic origin include sulphur and arsenate of lead.
4. Organic insecticides include synthetic materials like D D.T., Gammexine, organic compounds of phosphorus, etc.
5. Insecticides are most frequently applied as dusts, granules, sprays by hand or power equipment
6. In using insecticides great care is necessary to minimize adverse effects on useful insects (pollinating insects), fish, bird and other wild life.

IX SPACE SCIENCE

Outer Space and Rocketry

A. *Rocketry has helped the investigation of outer space.*

1. Ancient Indians and Chinese were acquainted with the science of rocketry.
2. Different types of fuels are used in rockets.

3. Multistage rockets have been constructed recently.

4. Rockets have been used to find temperature, pressure, density of the upper atmosphere, presence of meteorites, ionisation belts, solar radiation and cosmic radiation in outer space.

5. Outer space travel is full of hazards due to the presence of meteorites that move in it, cosmic radiation ionisation belts, intense X-rays and Gamma-rays.

Radar and Radio Astronomy

A. *Radar is used in the detection of various objects.*

1. Radar originated in the thirtees of this century out of a need to detect aircraft.
2. Page and Watson Watt made many improvements on it.
3. Radar helps the detection of thunderstorms.
4. Radio-waves are able to penetrate clouds, but are reflected by metals and other high density materials.
5. Radar has been used to determine accurately the distance of the moon and some of the planets of the solar system.
6. Three things are important in radar—range, bearing and elevation.
7. Methods of scanning and taking rough pictures of enemy targets have been devised by revolving radar beams.
8. Radar helps a pilot to have a visual picture of his target and to guide his plane.
9. Radio-telescopes are used in the investigations of radio stars and the universe.

Space Biology

A. *The atmosphere of the earth extends to about 960 km. Beyond this is the outer space which is a vacuum.*

1. The atmosphere consists of troposphere (11 km) statosphere (80 km) and the rest ionosphere

B. *Conditions in outer space are hostile to human life, the pressure is low and there is no air, no light, no gravity.*

1. Reduction in pressure produces morbid conditions and it affects respiration.
2. A person moving in a rocket is subject to several g. He experiences weightlessness at one stage.
3. The hazards in space include exposure to ultraviolet and cosmic rays.
4. There are also psychological hazards to be faced.

C. *Interplanetory flights will require a closed ecological system to be built up.*

1. Plants are required to regenerate the atmosphere. Algae like *Chlorella* have been considered to be useful to regenerate the air and provide food for the traveller
2. Microorganisms should be used to act on waste products and return the materials into the cycle.

Life of a Star

A. *Scientists presume that several physical processes take place before a star is formed.*

1. The surface temperature of the sun which is a medium type of

star is about 6000°C while its centre is estimated to be at a temperature of 20,000,000°C.

2. The source of steller energy is nuclear, obtained from the conversion of hydrogen into helium.
3. Measurements of light intensities of steller objects show that they release a very small part of their mass as energy every year.
4. The sun constantly emits electromagentic radiations in the form of ultraviolet and X-rays as well as particles of various energies.
5. It has a 11-year cycle of alternate periods of high and low sun spot activity
6. At the time of high activity it has thousands of flares and large magnetic storms.
7. The International Geophysical Year was organised to collect data to discover how the sun affects earth and its atmosphere.
8. In 1964-65 the sun is expected to have minimum activity. It has been proposed to organise an International Years of the Quiet Sun (IQSY). Forty nations including India are co-operating in this enterprise.
9. The IQSY will concern itself with space research, study of equatorial anomalies, synoptic studies of the atmosphere, study of ionosphere, geomagnetism, solar activity and cosmic rays.
10. Scientists believe that the sun will expand rapidly in radius in another six billion years and decline in brightness after that.
11. Scientists predict that when the sun increases more than four times its radius, the temperature on the earth will increase rapidly till it reaches more than 200°C and life on earth will cease to exist.

Central Coconut Research Station

THE coconut crop is of considerable importance in international trade as a source of coconut oil and coir goods. In India where it is also a food crop its importance is all the more, particularly in the State of Kerala which accounts for as much as 14 lakhs of acres out of the total Indian acreage of 17 lakhs under the crop. The coconut industry which was occupying an important place in the economy of this country in the early years of this century fell into a very bad state of affairs during the severe economic depression that struck the world in the early thirties of this century. In order to rehabilitate the industry the Government of India constituted in 1945 the Indian Central Coconut Committee and made it responsible for the development of coconut cultivation, its marketing and utilization in India. The Committee lost no time in reviewing the research work already done in India and accepted the recommendations made on future work. Two Central Coconut Research Stations were set up, one at Kasaragod for carrying out fundamental work on the botanical, agronomical and chemical aspects of the coconut and the other at Kayangulam (both in Kerala), for conducting investigations on the pests and disease aspects of the palm. The Madras Government's Agricultural Re-

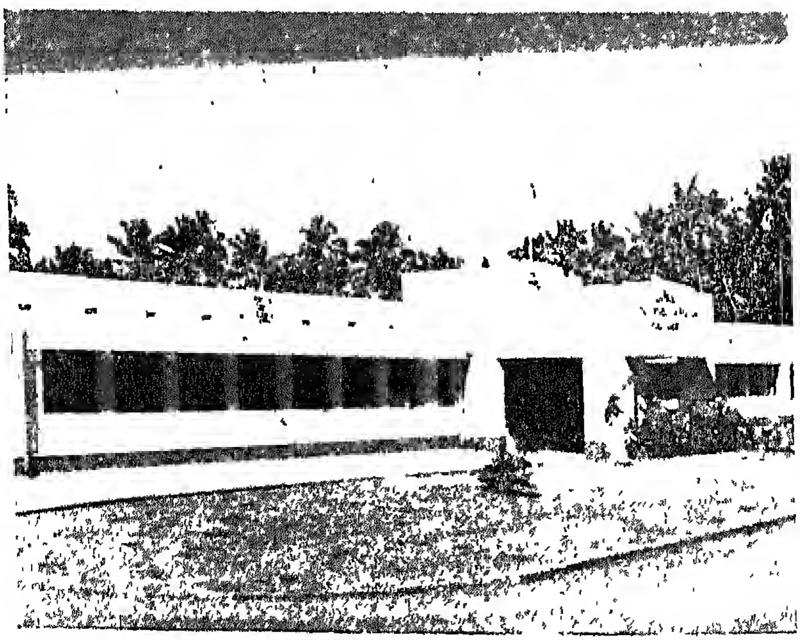


Fig. 1 The Central Coconut Research Station, Kasaragod

search Station, Kasaragod, which was in existence from 1916 was taken over and expanded with regard to area, additional staff and laboratory facilities. The Research Station is situated about three miles to the north of the Kasaragod Railway Station, and is now about 178 acres in extent. It has the unique advantage of having four different soil types, viz., white littoral sand, light sandy loam, red loam and laterite gravel. About 100 acres have already been planted while the rest are available for fresh planting which is now under way.

Research Work

The research work is being carried out in four sections, viz., Botany and Breeding, Cyto-anatomy, Agronomy and Chemistry.

Research work mainly of fundamental and applied nature is on the programme of the Station. In the Botany and Breeding section problems connected with the improvement of the crop by introduction, selection and hybridization are under investigation. Work in the Cyto-Anatomy section includes studies on button shedding and barren nuts, cytological and embryological investigations of the crop and allied aspects. The Agronomy Section is engaged in the investigation of the manurial, cultural and irrigation aspects, studies on green manure, keeping of flowering and fruiting records of trees, crop weather investigations, etc. In the Chemistry Section, soil survey of the coconut tracts of the West Coast, soil and tissue analytical studies with special reference to the nutritive aspects of the coconut under healthy and abnormal conditions and work on certain technological aspects of copra and coconut oil are under way. In short, all the agricultural aspects of the crop are receiving active attention.

Results of Research

Exotic varieties like Laccadive Ordinary, Laccadive Small, Straits Settlements, Fiji and indigenous variety Gangabondam are the types suitable for propagation in the West Coast.

Comparative study on the performance of Tall × Dwarf hybrids has shown that in annual out-turn of copra, the hybrids are better than random bred progenies of West Coast talls under Kasaragod conditions. In view of their early and heavy bearing characters they may also be propagated. For maximum production they should be heavily manured every year.

Study on natural cross progenies of dwarf has revealed that they are generally better than the artificial hybrids of Tall × Dwarf. Such natural progenies of dwarfs may be selected and planted wherever possible.

Regular cultivation and manuring of adult bearing palms has been demonstrated to be very necessary to maintain the yield at a high level particularly in soils deficient in plant nutrients. For most areas a manurial dose consisting of 3 to 4 lb of ammonium sulphate, 2 to 3 lb of superphosphate or bonemeal and 2 to 3 lb of muriate of potash would ordinarily be sufficient. In soils deficient in organic matter like sandy soils it is very necessary to apply a basal dose of cattle manure, compost or green leaves at 50 to 100 lb per tree per year.

Balanced manuring appears to be very necessary. Nitrogen is found to show its beneficial effect on early yield, i.e., in the

Fig. 2. The Coconut Nursery attached to the Station

third year itself but it has some bad effect on the quality of the nut. Potash on the other hand takes some time to influence yields but it has very beneficial effects on nut characteristics. Phosphoric acid has no pronounced effects on yield or quality of the produce.

Regular intercultivation of the coconut garden is very necessary to get maximum benefits out of manuring. Under West Coast conditions regular intercultivation by itself is able to increase yields even in the absence of manuring.

Among the different methods by which coconut gardens are intercultivated, the practice of piling mounds in August-

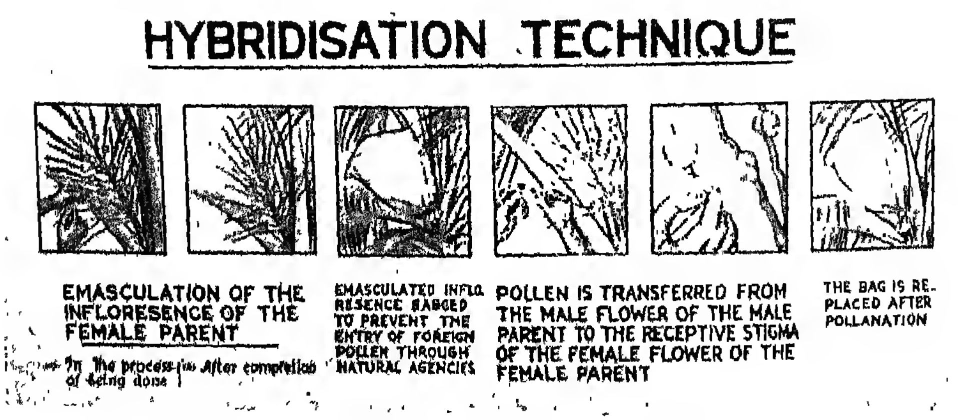


Fig. 3. The hybridisation technique as practised at the Station

September and levelling them in December-January is found to be more effective in increasing yields than digging, ploughing or forming basins, in red loam and sandy soils. Ploughing is, however, the cheapest of the operations.

Burying of dry coconut husks at 1,000 husks per tree in trenches 6′ wide and 15″ deep dug in between coconut palms has been found to be a very useful method of improving coconut yields under dry system of cultivation even in the absence of manuring. The effect of burying husks once lasts for about six years and the practice is remunerative in places where husk can be had cheap.

In littoral sandy soil areas along the sea coast, sea water can be used for irrigating coconut palms during summer months with very pronounced beneficial effects. No bad effects whatever have been noticed on the palms.

In sandy soil areas which are subject to considerable drought during summer months and where provision of irrigation facilities during such periods is a difficult problem, wilting of newly transplanted seedlings is of common occurrence. It has been shown that by burying husks in seedling pits at the time of planting or by mulching the pits with coir dust or saw dust according to availability, it is possible to reduce to a great extent the bad effects of drought. Provision of porous mud pots which need be filled up with water only occasionally as a source of moisture for newly planted seedlings has been demonstrated to be useful and to result in economy in the use of water.

A number of annual and perennial crops were introduced and studied for their suitability for being grown as green manure crop in coconut plantations. Among the annuals *Crotalaria striata* was

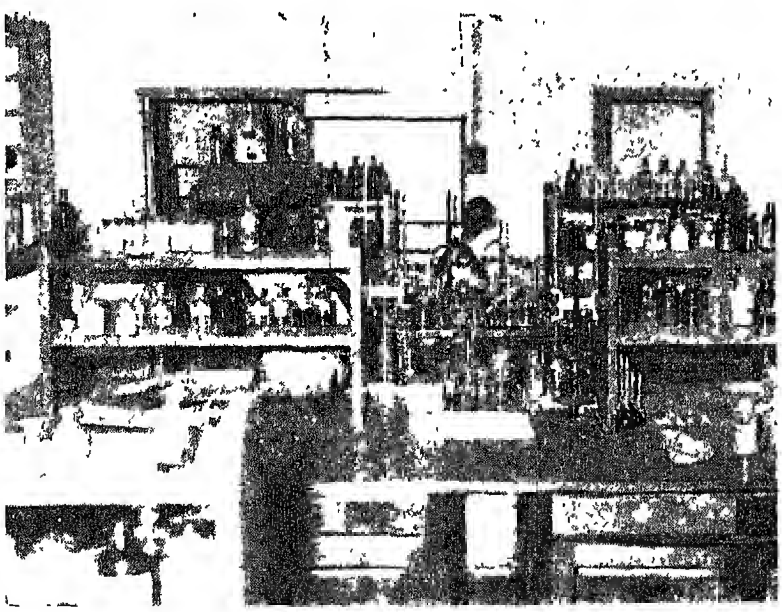


Fig. 4. Inside the Chemistry Laboratory.

Fig. [illegible]. Cultural operations in coconut garden.

found to be the best for growing in the plantations. *Gliricidia*, the quick growing green manure bush was found to be the most suitable for raising on the borders of the coconut plantation. Both have the very desirable property of not being relished by cattle. As a green manure cover crop *Calopogonium mucunoides* was found to be very promising.

Studies on the optimum pruning cycle of *Gliricidia* bush showed three months period to be the optimum on the West Coast. Pruning done in the months of June and September can be applied to the coconut palms while that of December can be put in cattle manure pits to prepare green leaf composts.

Storage studies of ripe coconuts showed that to store nuts without driage of nut water for a long period, the nuts are better stored in sand in the unhusked condition with the stalk end facing upwards. It was shown that husked coconuts can be stored up to eight months without driage by giving a thick coating of paraffin.

Common salt which is very widely used by coconut growers for application to coconut soils as well as to tops mixed with a little ash appeared from the results of both laboratory and field experiments to be without any significant influence on moisture conservation in the soil at the concentration at which it is usually applied. However, it does appear to benefit the soil by releasing some potash from the soil in an available form. Salt is not harmful to the coconut in any way when used in these concentrations.

Investigations on foliar yellowing in the coconut have shown that there is general improvement and amelioration in the case of trees which are supplied with a balanced manure application including N, P, K, Ca and the micronutrients.

Coconut materials such as leaves, petioles, spadices, trunks, etc., when left exposed to rain lose a good part of their valuable potash content due to leaching and so should be protected from rain when stored for fuel purposes so that the ash may retain its valuable potash moiety.

Studies on the mechanical drying of coconuts showed that the drying occurred in the falling rate period and a maximum of 70°C can be employed for producing good quality copra.

Sulphuring the copra was found to help to preserve the natural colour of coconuts and give at least partial protection from mould and insect attack and the sulphured copra had better preserving quality.

Studies on the 'rationale' of various household methods of storing coconut oil have shown that heating the oil after addition of substances like salt, jaggery, ripe plantain or cooked rice, etc., helped to minimise the development of free fatty acid in the oil during storage, and preserved better.

Other Activities

Besides regular research work, certain specialised units of studies are also attached to the different sections. Thus the soil survey unit is engaged in soil survey of coconut growing areas and giving useful advice to coconut growers. The coconut survey unit attempts to collect new and promising varieties and types from other coconut producing states in India. The meteorology unit regularly collects weather data from the Meteorology observatory attached to the Station. The statistical unit besides giving advice in the layout of experiments, collection, analysis and the interpretation of data, is also engaged in investigating the methodology of experimentation on the coconut crop. Under a Seednut Procurement Scheme about 2 to 3 lakhs of high quality seednuts are being collected every year from the Badagara and Tripura States. About 20,000 good quality seedlings are also being produced on the Station itself for supply to growers.

The Station is maintaining close liaison with the Community Development Departments and takes part in exhibitions, seminars and conferences organised by them from time to time. Short term training courses are also arranged both for technical people and laymen according to requirements. A popular advisory service is helping the growers to learn more about improved method of coconut cultivation. The findings of research are regularly published in the *Coconut Bulletin* and the *Indian Coconut Journal*.

The Station is thus actively engaged in a multi-phased programme of work to help to step up the production of coconut and make the country as far as possible self-sufficient.

Classroom experiments

ANIMAL WAY OF LIFE

THE animals adopt various methods for capturing and procuring their food. A study of their habits is a part of the study of life functions of animals. In this experiment, a method of studying such habits in *Paramecium* is described.

A culture of *Paramecium* can be started, as described here, some days before the experiment. Boil one litre of pond water and add a handful of dry hay. You may also add a few grains of wheat. Boil these for another ten minutes and allow the mixture to cool and keep this for two days. Keep the flask or container plugged with cotton. Inoculate this mixture with a little pond water taken from the bottom of the pond. This water is likely to contain *Paramecium*.

Prepare yeast suspension. Take half a tablet of yeast in 50 ml of water and allow this to stand for 24 hours. Just before the experiment, boil the yeast suspension with 0.1g of Congo red powder. Keep it boiling for eight minutes over a low flame. Allow this liquid to cool.

Prepare methyl cellulose by adding 90 ml of water to 10 g of methyl cellulose. This will give a thick syrupy solution which when added to any culture of protozoa, slows down their movement so that one can observe easily the microscopic organisms.

Prepare a ring of methyl cellulose on a glass slide and place a drop of *Paramecium* culture in the centre and add a drop of yeast suspension. Cover with a cover glass and observe the *Paramecium* cells under the microscope. Observe how the cells eat (ingest) the yeast cells. Note the

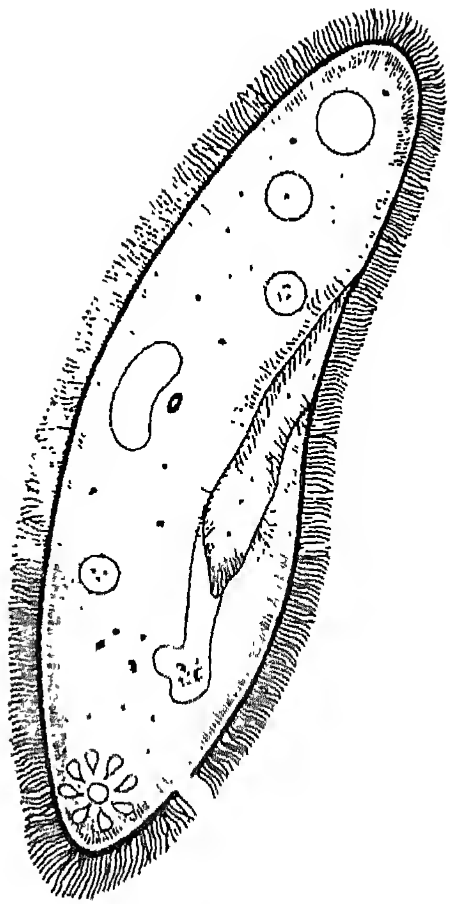


Fig 1.

colour of the yeast cells as they enter the cell and get enclosed in a food vacuole and the change of colour of the yeast cell later on. The change in colour will be so rapid and one should carefully observe the changes. Congo red has a red colour at pH 5 and blue at a pH 3.

The yeast cells at first are red or pink and they enter the oral groove and move into the gullet. As the vacuoles travel in the cell the colour changes from red to blue which shows that the food is now in an acidic medium. Certain enzymes are now acting to digest the food. After some more time a different set of enzymes may act and the colour of food vacuoles may again change to red. Finally the undigested matter will be ejected.

Thus the process by which *Paramecium* ingests, digests and egests the food can be observed clearly.

(Adapted from, *Biological Science: An Enquiry into Life,* (BSCS Yellow Version) Student Laboratory Guide. Harcourt, Brace & World, Inc., New York, pp. 153-154. 1963.)

S. DORAISWAMI

DETERMINATION OF THE DENSITY OF A LIQUID USING A LOADED TEST TUBE

THE density of a liquid can be determined by floating in it a loaded test tube. A wide test tube is fitted with a mm scale by inserting a strip of mm graph paper inside it. Sufficient lead shots are placed in the tube to make it float vertically in the liquid whose density is to be determined and the level (x_0) at which it floats is read. Additional weights are then placed in the tube and in each case the reading (x) of the scale against the liquid level is noted.

A graph of depth of immersion, (d)$=x-x_0$, against the additional load is drawn. The external radius (r) of the tube is found out by using callipers, taking at least four readings and then taking their mean. Any point A is taken on the curve and perpendicular AB is drawn to the X-axis which represents additional load as shown in the Fig. 2. The density is found out by using the formula

$$\rho = \frac{OB}{\pi r^2 \times AB} \text{ gm/ml}$$

The formula used can be derived in the following way:

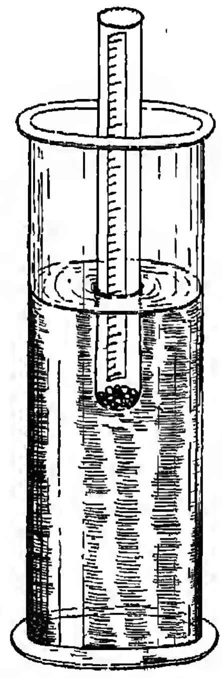
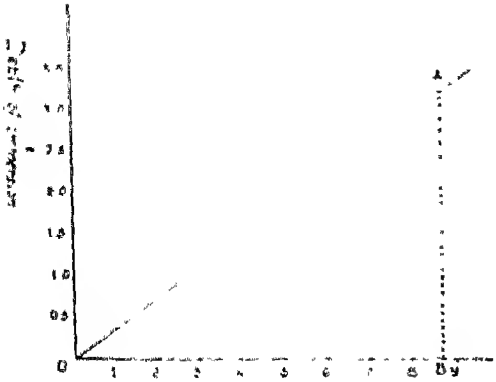


Fig 1.



Additional load

Fig. 2.

Let the radius of the tube be r cm and the mean depth of immersion in cm per gm be n (from the graph n=AB/OB). Then volume of liquid displaced by the addition of 1 gm wt to the tube $=\pi r^2 n$ ml. If the density of the liquid is ρ gm/ml, then the weight of the liquid displaced $=\pi r^2 n\rho$ gm. By Archimede's principle

$$\pi r^2 n\rho = 1, \text{ or } \rho = \frac{1}{\pi r^2 n} = \frac{OB}{\pi r^2 \times AB}\text{gm/ml.}$$

$$\therefore \rho = \frac{OB}{\pi r^2 \times AB}\text{gm/ml.}$$

MAHINDER KUMAR BAHL

Science abroad

Current Trends in Chemical Education in United States High Schools

James V. De Rose

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IF I were not a science teacher, I am confident that I would be very much confused with what I call the 'alphabet' courses that have appeared on the secondary school educational front. The courses in many schools in the United States today include such titles as PSSC physics, CBA chemistry, CHEM-Study chemistry, BSCS yellow version biology, BSCS blue version biology, BSCS green version biology, SMSG mathematics, to name a few. I consider the changes that are taking place to be vital ones, important to all of us as teachers, parents and citizens. This paper is an attempt to tell you about the 'Revolution in Science Teaching' taking place in the United States and its effect on schools, teachers, and children.

BACKGROUND FOR CHANGE

Norman Cousins has been credited with saying that the 20th century is at least a 1000 years beyond the 19th century. *Chemical and Engineering News* has put it in another way: 'Young scientists entering industry today have only a breather before they must plan to refresh knowledge and techniques, because at the current rate of discovery, their training will be adequate for about five years.' Statements have been made claiming that our knowledge of chemistry has been doubling every decade since the 1920's How can we prepare youngsters adequately to live in a world in which science is changing so rapidly? Unfortunately, as Dr John Baxter of the University of Florida has stated, 'the brainpower of our students

The author is the President of the National Science Teachers Association of United States of America.

does not double every decade'.

For many years the inadequacy of science instruction from the point of view of methodology and content has been a subject of criticism by many scientists and science professors in colleges and universities. Dissatisfaction stemmed primarily from the fact that textbooks presented a fragmentation of ideas and did not reflect science as it is known to scientists. Laboratory experience for the student was minimized and what was being done was largely 'cookbookish'.

Fortunately, many scientists and science professors were not content to criticize but honestly faced up to the responsibility for the unhappy state of affairs. Dr. Glenn T. Seaborg expressed himself in this manner :[3]

'We need not go into all the reasons for the shortcomings of high school chemical instruction except to emphasize one reason for which most of us carry a heavy share of the blame. I refer to the surprising and persistent general lack of interest in high school chemistry and lack of communication with high school teachers and administrators on the part of college professors of chemistry and professional chemists.'

NSF AND NEW PROGRAMMES

Although private agencies, such as the Ford Foundation and the Carnegie Corpoportions have provided some financing, the U.S. Government, through the National Science Foundation, has been largely responsible for the series of massive secondary school curriculum revision projects which were started in 1956 with the Physical Science Study Committee project in PSSC physics. In 1957 the idea was generated for the Chemical Bond Approach project and the first writing conference was held at Reed College in 1959. In 1960 both the Chemical Education Material Study, known as CHEM Study and the Biological Sciences Curriculum Study, known as BSCS, held writing sessions and initiated curriculum projects. The School Mathematics Study Group was established in 1958 and is one of several curriculum projects in mathematics. Similar projects have been started at the elementary and junior high school levels in mathematics, geology, and general science.

The NSF-sponsored experimental curriculum revision projects have been most successful in presenting the essential ideas which insure the greatest ultimate understanding of a subject. In addition, the student gains an insight into the manner in which knowledge is acquired. The authors of the new curricula have not written only of the results of scientific investigations but also of the thinking, planning, and interpretation associated with research. The quality of secondary-school instruction has improved to such an extent that the editors of *Time* reported :[4]

'Until lately, the favorite complaint of U.S. colleges was that high schools sent them immature and unscholarly freshmen. Now the tables are about to be turned. Ill-prepared for doubled enrolment in the 1960's, colleges also face a sharp rise in ability - the nation's better high schools are improving so fast that their top graduates are too good for ordinary colleges, and too numerous for the best ones to handle.'

CBA and CHEMS

Our major interest is to discuss the current trends in chemical education at the secondary school level. CBA and CHEM-Study are the two curriculum projects in chemistry which are revitalizing and reorienting the teaching of chemistry in our secondary schools. As a matter of fact, I should add that they have been a shot in the arm to the faculty of college chemistry departments since they too are now taking a sharp and critical look at the courses which they are offering.

In the space available, it is impossible to give you the details of these new curricula. The easiest thing to say is that they are modern courses in chemistry which present in a definite, unified and sequential pattern a variety of essential concepts based on the topics of model building, equilibrium, thermochemistry, stoichiometry, electrochemistry, properties, structure, bonding, reactivity, and acid-base theory in terms of Lewis, Bronsted-Lowry, and Arrhenius.

The pattern of the CHEM-Study approach involves three major divisions.[5] The first section, which covers the first six chapters, is called the overview and is intended to give the student a broad view of chemistry. It deals with what chemistry is about and introduces the student briefly to the basic ideas which are to be expanded later. The next eleven chapters are intended to provide the basis for understanding chemistry and treats the theoretical concepts of energy effects, kinetics, atomic structure, bonding, equilibrium, and emphasizes the predictable nature of chemistry. In the final section of the book the transition elements, biochemistry, the halogens, and other topics are studied in detail applying the previously developed concepts and principles. Dr. Irving Siegelman, formerly of the University of Pennsylvania, compares the overview to the view of the main roadways one would get from an airplane, the development of concepts in the second section as an exploration of the byways and highways which branch from the main roadways and the last section could be compared to taking a closer look at some of the cities and towns located on these roadways.

The CBA approach was organized with bonding as a central theme.[6] The thought was expressed that chemical systems have structures and that a chemical reaction can be interpreted in terms of the making and breaking of the bonds which hold atoms together. Although the central theme is concerned with the structural changes, the student quickly discovers that one cannot think of structural changes comprehensively without also considering the energy transfer associated with the change. Still later, energy and random arrangement are linked in the treatment of chemical systems in the equilibrium state. The student also observes that reactions take time and this is sufficient to introduce reaction kinetics and reaction pathways. The course, then, does not have one theme but several treated concurrently.

Dr. A.H. Neidig, Lebanon Valley College, associates the main bonding theme of CBA to the trunk of a tree and other important concepts such as energy, kinetics, model building, mechanisms, equilibria, and stoichiometry as the major branches of the tree. You still need smaller branches and leaves to complete the tree and these represent the descriptive chemistry which is used as the medium for considering the major ideas of chemistry.

The Process of Science

However, the impact of these courses is not due primarily to the modern content which they include but because they are designed to involve students directly in the processes of inquiry. The attempt is made to reveal the nature of science as an intellectual enterprise based on laboratory investigations. These courses are based on the laboratory, and stress the element of research in addition to the product of research. The content and process dimensions of science are not presented separately.

Theories are not divorced from the data which support them. Science is not presented as knowledge true and permanent. The texts are written and laboratory experiments designed to reveal science to students as inquiry with all its successes, defeats, and limitations.

Students learn that there is a distinction between what can be discovered in the laboratory and the mental inventions or models which men create in an attempt to explain these observations The authors use original data obtained by scientists. In the CBA text, for example, in developing the relationship known as Coulomb's law, the data obtained by Coulomb himself in 1785 are studied by our students. The reasonableness of Coulomb's interpretation with due consideration of the uncertainty associated with all data are discussed. Students are given the opportunity, as Dr. Joseph Schwab of the University of Chicago has ably said, 'to understand the ways in which invention and observation, datum and conception, interpenetrate to form the growing fabric of scientific knowledge'.[7]

Typical Experiments

To a large degree then, the designers of these curricula have attempted to put students in positions in which learning results from their own efforts to explore, question, and find answers What questions can be asked for which answers can be found? I will briefly describe the CBA approach taken to one such question which is used to establish one basic notion inherent in the understanding of the mass and mole relationships of a chemical change as expressed by a balanced chemical equation. The question may be posed in this manner.

Silver nitrate solution is added to an equal volume of sodium chloride solution. The precipitate is removed by filtering The student is then asked: What will happen if an additional portion of either of the original reagents is added to the filtrate? The student divides the filtrate into two portions. Silver nitrate solution is added to one portion, sodium chloride to the other. Since the students have used a variety of concentrations, the results obtained are not the same for all students. Some will find that a white precipitate will form when additional NaCl solution is added, others only when additional $AgNO_3$ solution is added, and others may find practically no precipitate or a slight cloudiness when one or the other reagent is added. To the beginner in chemistry, this presents a bewildering set of observations for which an explanation is needed. He is thus exposed to the methodology of the chemist who is constantly dealing with 'black boxes.' In considering the problem students get involved in the process of science.

There is no question about the evidence. The observation can be made. The data can be collected. In this case, an explanation is needed. Students cannot avoid mental involvement (although some fight

it) in developing the kinds of explanations which can be validated by further investigation. As a result of this experiment students suggest that when two solutions react, an excess of either reagent will not react. This is a fundamental understanding of chemical change which we want to establish. What are the implications of this explanation? Is there any way we can test it? If this is so, shouldn't the quantity of precipitate we obtain vary with the quantity of solution used? If we keep the volume of one reagent constant and add different volumes of the second reagent shouldn't the quantity of precipitate vary accordingly? As a consequence, the attempt to explain the results of one investigation becomes the basis for another In this case, another chemical system is used and the question posed may be stated in this way What is the relationship between the volume of reacting solutions and the quantity of precipitate formed?[8] The investigation of this problem makes use of a concept developed earlier, expands it and eventually leads through further experimentation to the discovery and understanding of the mass and mole relationships among the components of a chemical system

Reaction of Teachers

How have teachers reacted? In making a judgment here I will just state that although no firm figures are available this year (1963-1964) there is reason to believe that about 900 teachers and 75,000 students out of approximately 400,000 students enrolled in academic chemistry were involved with these new courses in 1962-63 Many of these teachers have received training at summer institutes. The real test of acceptance will come within the next two years I am confident that many teachers will find these new courses stimulating although I believe that some may find it difficult initially to change their mode of teaching. Students must understand that there is no easy way to learning, it cannot be delegated, it must be individual. The responsibility for learning must rest with the student and not with the teacher. Students' attitudes must change and so must ours as teachers Our students view us as information dispensers and we are largely to blame for this image because of our assertive manners Our function is to provide opportunities for young people to learn. One of the best ways to give a student an appreciation of chemistry is to make it possible for him to perform the functions characteristic of chemist. In addition, we as teachers must learn that we can also provide the means for our self-education while we provide for the education of our students. It is not necessary to depend on refresher courses. The only way to 'cover' and keep up with changes in science is to read both extensively and intensively. What we recommend for our students we must do ourselves. Teachers too must become scholars.

SUMMARY

Briefly then, the trends in chemical education as I see them are these:

1. New courses in chemistry are written so as to reveal the underlying structure of chemistry and the attitudes and processes of inquiry responsible for its development.

2 Outstanding chemists have decided what it is that constitutes the unifying structure of the subject.

3. A sharp distinction is made between facts and attempts to explain them,

Theories are taught not as truths but as models, and students are asked to participate in the model making.

4. An effective working partnership and liaison has been established among high school teachers, college and university professors, and professional scientists. Decisions involve many minds from all levels of participation.

5. Strong emphasis is placed on the laboratory and investigations are designed to permit the student to discover for himself. Laboratory techniques are taught as means to an end and as an end in themselves. The emphasis is on the chemistry involved in the experiment.

6. The image of the teacher of chemistry is changing: he is not a dispenser of knowledge but a scholar who draws his students in as partners in a common study of science not as a body of knowledge but as a rational enterprise.

7. More participation is required of students. Experiments are not repetitive or demonstrative in conception but require original thought and planning. Students are provided with an intellectual atmosphere and are not permitted a passive role.

In closing I want to emphasize that the development of new curriculum approaches in science would not have been possible without the financial support of the National Science Foundation and several independent foundations. The financial support made it possible to enlist some of the best minds available and conduct experiments in curriculum development on a national scale. These new courses which I referred to briefly in my opening remarks reflect the concern and interest of the federal government in improving science instruction in all of the schools in the nation.

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The Advancement of Natural Science Teaching in Foreign Countries

K. Hecht

DURING the last few years I have made some interesting observations concerning the prestige attaching to natural science and to science education in the foreign countries I visited on behalf of my firm, Messrs. Leybold. These visits were generally suggested by the annual congresses of foreign teacher's associations similar to the one we are now attending in Frankfort. Being a member of several foreign physics teachers' associations I had the opportunity of delivering demonstration lectures in the course of which, sometimes on special invitation, I could report on West German efforts to enhance physics education. I also attended two international conferences, viz., the International Conference on Physics Education held by the International Union for Pure and Applied Physics (I.U.P.A.P.) in Paris in the summer of 1960, and a conference on the place of science in the recreational activities of youth that was held in Liege in the autumn of 1960, at the suggestion of the Council of Europe.

All these meetings provided opportunities for talks and discussions on schooling conditions at home and abroad, on the percentage of periods allowed for science teaching, and on the prestige attached to a science education outside school. These direct impressions extended considerably my knowledge of the methods of physics education and of the various ways in which a common goal is sought.

The observation that, in all the other countries, the general attitude towards science is much more open-minded than here in Germany (which I found confirmed every year that I repeated my visits) was the initial reason prompting me to tell you of this striking fact.

It is not possible with ease to talk simultaneously about all the countries where these conditions attracted my notice. I think it best if I restrict myself on the whole to the impressions I received in the course of several visits to England, and only supplement these in a few cases by additional information about the United States. No doubt one could just as well talk about our near neighbours, such as France, Austria, Switzerland, the Scandinavian countries, Holland, and Belgium, where similar observations can be made.

Whereas we watch with grave concern the published plans for the reform of German school teaching, especially the Draft Agreement of the Ministers of Education, and have to note a growing tendency to cut down on science education, especially in the upper classes of the gymnasia, other countries are working out new curricula with a greater science bias, introducing science training courses,

From a lecture delivered by K. Hecht in April, 1961. Reprinted from Die *Leybold-welle* The LEYBOLD House Magazine of Physics Apparatus for Trading Purposes, 2 (7-8), 1962. By Courtesy of the Embassy of the Federal Republic of Germany in New Delhi.

and stressing in international committees the importance of science as a subject of teaching. To quote an example: the previously mentioned International Conference on Physics Education of the I.U.P.A.P.[2] has stressed in its resolutions that physics was an essential factor in the intellectual life of our day and should be made accessible to all children at all levels of education. This would, according to the I.U.P.A.P., necessitate essential improvements in physics education, more active training of teachers, and the creation in schools of other facilities essential for successful physics teaching.

At the Liege meeting, which was concerned with spare-time science activities of school children outside and beyond the training they receive in school, the premises were the same, i.e., that the present-day impact of science on our thoughts and our way of life should be reflected in the special attention it receives at all levels of teaching and education.

In England, the Science Masters' Association (SMA), which resembles our Fordervercin, and the Association of Woman Science Teachers have for years concerned themselves with plans for a reform of science teaching in British schools. Their first suggestions dating back to 1957 have been published again at the beginning of last year[3] after extensive discussions with the authorities concerned, with interested organizations and even with the press. The basic assumption underlying these plans is that the number of periods now reserved for science teaching is insufficient. The influences of science, claims the S.M.A., so increasingly affect our life and thought that no one wishing to be considered, in any way, educated can afford to ignore it. Further an insight into the teachings of science would reveal its great influence upon human thought and account for its central position. Hence the schools are inevitably faced with the responsibility of focusing similar attention on science as was formerly concentrated on the humanities, and of ensuring for it the same consideration as for mathematics and the mother tongue.

On these principles the S.M.A. suggest that, during the first five secondary school years preparing for the General Certificate of Education, Ordinary Level, a minimum of 6+6+9+9+9 compulsory natural science periods a week should be provided for all secondary school children alike to cover physics, chemistry and biology. The sixth form preparing for the General Certificate of Education, Advanced Level, which qualifies for University Entrance, can be likened to the upper classes of our secondary schools. For this last form the S.M.A. suggest a splitting into two courses, course A being intended for all students, especially for those not intending to specialise in science, and course B for future scientists. They suggest that out of the total of 35 periods, two be allotted to science in the case of course A, and seven in the case of course B. The more general course A is intended to consolidate the knowledge acquired in former years. The non-specialist is to be introduced to the scientific method using as examples a few carefully selected problems of science. Course B, on the other hand, provides

2. International Education in Physics, Proceedings of the International Conference on Physics Education, Unesco House, Paris 1960, N.Y. and London 1960, p. 1

3. Science and Education Policy Statement, John Murray, 1961.

students specially interested in science with the corresponding possibilities of deeper penetration

The suggestions expressly provide a close co-operation among the individual science subjects. The curricula worked out provide interesting examples of this Thus physics teaching is relieved of some of its burdens by leaving it to chemistry to explain certain relations the chemist requires as well. This avoids unnecessary duplication of effort without neglecting comparisons.

Anyone trying to compare these S.M A. plans with conditions found in German secondary schools must bear in mind the many differences between the two school systems. In particular, the traditional restriction to three main optional subjects in the 6th form cannot be compared with the methods we employ in the upper classes of our secondary schools, but the percentage of total teaching periods reserved for science subjects can very well provide a suitable basis for comparison. It is 17% in the first two secondary school years, 25% in the middle three, and in the last two it is 6% in the case of course A, and 20% in the case of course B. Thus the average percentage of science periods (17 6% and 21.7% respectively) is considerably higher than it used to be in German schools, and the Draft Agreement even permits complete non-attendance of these subjects in the upper classes.

On applying the spirit of the S.M.A. plan to German secondary schools the following pattern is obtained: the curriculum provides science subjects instruction which is compulsory for all pupils in the lower, the medium, and even the upper classes. Of the total time available for instruction, 17% is reserved for the basic science taught in the lower classes, and 25% for science teaching in the middle classes The three science subjects are treated on an equal footing but the correlation of the subject-matter presented is emphasized. For the upper classes, this plan would entail a splitting up into a science stream and a humanities stream In the humanities stream the natural sciences would be allotted 6% of the total number of periods, and in the science stream 20% each of the three subjects receiving equal consideration.

It is just and proper to ask how it is possible that plans are being discussed in other countries which involve a much greater consideration of science than is thought necessary in Germany Yet it is not certain that the mentioned S.M.A plans in England are outstandingly partial to science I am convinced that in other countries, especially in Russia, even more time is being devoted to science education. On trying to find an answer to this question what struck me again and again in the course of discussions abroad was that hardly anybody seems to find anything suspect or sinister in the pursuit of science, or for that matter, of engineering, in contrast to what one hears time and again in the course of similar conversations in Germany. Abroad, no one seems to think that science might seduce youth into materialism, or that true education can only be achieved by a study of the humanities Obviously people abroad are much more open-minded towards science and its bearing on our culture, and towards the tasks this sets for this and future generations. Let me streng-

then this argument by quoting some examples from England.

Among the public institutions engaged in the advancement of science the Royal Institution is the oldest and the most revered. It was founded in 1799 by Count Rumford. He had previously been in Bavarian service. There, he had conducted his research on the production on heat by friction which is referred to in physics teaching. The articles of the Royal Institution declare it to be a 'public institution for the advancement of science, for the introduction of useful inventions and improvements, and for demonstrating in lectures and experiments the usefulness of science to the general public'. The Royal Institution has continued to this day and is an honoured public society, it is still accommodated in the same building in Albemarle Street, London, where it took up quarters at the time of its foundation. Sir Humphrey Davy delivered his famous lectures as a successor to Count Rumford, and conducted scientific research in the laboratories of the Royal Institution. Anyone visiting the Royal Institution can see above the mantelpiece as he steps through the columns into the great hall a plate commemorating these lectures. This plate tells how, in 1812, a young man was given tickets for the lectures of Sir Humphrey Davy; his name was Michael Faraday. Later on he became co-worker and successor, and made his famous discoveries on electrostatic induction, the laws of electro-chemical equivalents and the principles of electromagnetic induction there; he instituted the Christmas Lectures, public lectures addressed to London shool childern and held about Christmas time, and otherwise promoted the contact with science of the London society in a lecture room that still exists and is frequently used. On calling to mind Faraday's last lecture on 'The Natural History of a Candle' one receives a vivid impression of the activities of the Royal Institution at that time.

The influence and the activities of the Royal Institution have continued to grow under Faraday's successors. When one hears names like Thomas Young, John Tyndall, Lord Rayleigh, J.J. Thomson, Lord Rutherford and those of similarly outstanding English scientists, and knows that all these gentlemen availed themselves of the educational work of the Royal Institution, one can imagine the beneficial effects of this traditional contact between science and the general public in that country. At present Sir Lawrence Bragg, who was awarded a Nobel Prize, is the scientific head of the Royal Institution. He has extended the lecture service and the lectures delivered to school children and has seen to it that over and beyond the circle of the members of the Royal Institution anyone can receive a good and direct knowledge of the development of science. To this day the most outstanding British scientists are among the lecturers and sponsors of the Royal Institution. It is not considered a burden, but an obvious duty, to give intelligible presentations of one's own special field of work in science, especially within the Royal Istitution. Twice I was pleased and privileged to attend the Christmas lectures in the last few years. All the front seats were reserved for schoolboys and schoolgirls, the grown-ups had to sit in the last few rows. The children follow the lectures and demonstrations with great interest. Generally small exhibitions are held in

addition. Recently the Royal Institution has begun to hold similar lectures and exhibitions in other towns as well.

In Germany we have nothing resembling the activities of the Royal Institution. Of course we have a number of scientific societies and public institutions, which have set themselves similar aims; but their sphere of activity is much more limited than that of the Royal Institution We all feel very happy that the Deutsche Museum in Munich has been rebuilt, that increasingly more stress is being laid on its educational aspects, and that Professor Auer is at present delivering public lectures on science there. We are also glad that the URANIA society in Berlin was re-established and is making plans to supplement its science-lecturing activities by simple experiments to be performed by the visitors themselves. Nor should we forget the Rontgen Museum in Lennep, or the former Senckenbergische Naturforschende Gesellschaft in Frankfort. The activities of all these institutions should be considerably extended in order to create that close contact between science and the general public which is so urgently required these days and which is achieved in such an exemplary manner by the Royal Institution.

Even more than the Royal Institution the British Association for the Advancement of Science has undertaken to present science to the general public. This society was founded in 1931 on the initiative of the well-known English physicist David Brewaster. It was modelled on the Deutsche Gesellschaft für Naturforscher and Arzte, then 9 years old, out of a feeling of concern for the development and advacement of science in England. Its main activity at the outset consisted in holding a yearly science meeting to promote co-operation among research workers and those interested in the applications of science. From the beginning the organisers abstained from restricting these annual meetings to university towns; on the contrary, the towns visited were preferably those not provided with universities of their own. The society even met overseas on several occasions, e.g. in Canada, South Africa, and Australia. A few years after its foundation the scientific members of the association deemed it their duty to read papers in public on their special fields of work at these yearly meetings. After some initial hesitation these papers, intended to be intelligible to the general public became a permanent feature of the annual meetings. In order to extend the circle of persons reached by the activities of the association local branches whose activities would not be restricted to the yearly meeting were founded. Seeing that the laboratories of the Royal Institution had for many years played an outstanding role in British research, the British Association began to promote research. For many years it owned an observatory in which many scientific investigations were carried through, and which later on became the nucleus of the National Physics Laboratory as a result of the numerous thermometer and barometer calibrations that had been performed there.

Now-a-days the British Association has considerably extended its activities. The nucleus of these is the yearly meeting attended by 3,000 to 4,000 scientists, technologists, teachers, students, engineers, industrialists and other interested laymen. Sessions at which papers are read and discussed are held in 16 different sections

under the guidance of actively participating scientists of distinction. Special meetings of the same nature are arranged for young participants. During the week of the congress the press, broadcasting and television services give special coverage to the papers and lectures. Even months later the papers read at the meeting are discussed in public, as is shown by detailed enquiries from the public.

In recent years the British Association has instituted a central lecture service, with the object of extending its activities beyond the yearly meeting, and of ensuring throughout the year that in as many places as possible the desired close contact between scientists, industrialists and interested laymen, is maintained especially among the younger generation. These projects were willingly assisted by British industry. District groups were set up and with their help some hundred scientists including many of the most distinguished were persuaded to give lectures. Only those known to have the gift of presentation, to select subjects of general interest, and to treat them in a manner intelligible to the audience were approached. As the lecturers only take a nominal fee, and the organization of the lectures is to a great extent based on voluntary work, the Association can pride itself in maintaining, on an average, expenses at £ 4 to 6 per lecture.

This extensive lecture service is not restricted to science meetings. It also covers meetings of industrial organizations, teachers' associations, education centres, and above all of youth clubs. Some schools regularly request lecturers from the Association. These lecture to the school children and their parents outside school hours on interesting scientific topics. The school science clubs existing in many English schools are enabled to meet eminent scientists in much the same fashion. This provides them with many a useful impulse for their club work. One is surprised to hear how many hundreds of such lectures to grown-ups and youths have been delivered by British scientists in the course of the last few years on the initiative of the British Association.

If, in England itself, there is a feeling that even this is not enough for the contact between science and the general public, then in my view this means that this important problem is being appreciated there to a greater extent and that more is being done towards its solution than in our country. This is also shown by the fact that the major daily papers give much more and better coverage to scientific and technical events than is normal in Germany. In an atmosphere of such intensive struggle for mutual understanding the importance attached to science education is rather different from what seems to be intended by the Draft Agreement of the German Ministers of Education. Thus the S.M.A. was able to discuss its suggestions with all specialists in the field and is apparently having a good chance of seeing them put into practice in the near future. Such a detailed discussion by a wide public is a proof of the general appreciation of the importance of these problems of school teaching and forms a remarkable contrast to the way these matters are usually settled in our country.

Another proof of this spirit of co-operation is the award of research grants to individual science teachers by the Royal Society. Even though the sums involved

are always small, the fact that teachers are enabled to do original work in science that is recognized by the most eminent scientific society of the country seems to me to be yet another sign of broad minded co-operation. The same can be said of the relation between industry and the schools. When the public discussion on whether or not to extend and improve science teaching was going on in England, leading British business magnates came together a few years ago in order to discuss with the schools what could be done in the matter. At that time 140 firms agreed to donate a sum of more than 2½ million pound sterling. A commission set up by them visited the schools and provided those deemed worthy of aid with assistance from the fund.

If, in conclusion, I make some remarks about my impressiosn from the United States I feel convinced that everyone in this audience is aware from the outset of the special appreciation of the American public of science and engineering and thus of science education. Arter all, that country has had the most explosive technical evolution. This accounts for the interest centred on educational matters over there, and which to us is quite sensational. The National Defence Education Act instituted by President Eisenhower had its funds considerably increased by President Kennedy. These funds are primarily intended for science and foreign languages teaching, both receiving about equal consideration. Moreover the individual states, counties, and towns provide large sums for building and equipping new schools. In addition there are funds from foundations established by firms and scientific organizations. The universities and colleges have also shown remarkable interest in matters of science education. In several places committees are busy working out new curricula and methods of teaching Among them the Physical Science Study Committee which was on the whole called into being by M.I.T. professors, has become particularly well known. Many high schools have instituted teachers' training courses with the aid of public funds. In the USA too, youth science clubs perform a very useful function in scientific and technical education. The many evening classes for adolescents and adults, the scientific television programmes that are very freqently supervised by universities, clearly show the general sense of responsibility of the public in these matters. The problems with which school teaching is faced over there now-a-days are not at all connected with the appreciation and valuation of science within the educational functions of the school. One cannot understand them without a detailed knowledge of the differences between the American and the European educational system I cannot dwell on this subject for lack of time and in order not to depart unduly from the subject chosen, which was to enquire whether or not other countries are essentially more sympathetic towards science and science education than Germany. The above details show clearly enough that this is so in the USA as well.

As I said in the beginning, other European countries could also be cited in support of my argument. Of special institutions existing in the various countries one might mention, for example, the new movement 'Science and Youth', a kind of most intensively run science clubs for young people, in the case of

France, or several very active institutions of science teaching in the case of Austria, the excellent newspaper coverage given to science and engineering in Switzerland, and the Workers' Educational Classes (Volkshochschulen) in the Scandinavian countries. Nowhere would one find a tendency to treat science in this modern age as an unimportant optional subject ranking below other subjects of teaching.

In the foregoing I have tried to convey to you some of the impressions relating to science teaching that forced themselves upon me in the course of repeated visits abroad. They can be summarized by the regrettable statement that the general appreciation of science and, therefore, the spirit of co-operation on questions of science education are considerably lower in our country than abroad. The reasons for this are certainly very difficult to detect. The history of the German mind and the German political and social development differ in many aspects from those of other peoples. However this may have been caused, our present-day situation is certainly no different from that of the countries about us. In the long run we shall not be able to afford luxuries which load our young people with grave handicaps for their future tasks in life. On the contrary, it will be imperative to give more thought to the presentation of science to the general public than has hitherto been done. Once the need for the extension of scientific research, the application of the results of science, and the teaching of basic science at school has come to be recognized as an urgent necessity, science will no longer remain an esoteric skill of a few initiates, but will receive its due appreciation from all quarters. We shall have to ask our research workers to intensify their efforts in this respect. Our scientific societies should see their field of work among the general public and not only within the limited circle of their members. Above all we would wish that those not so directly connected with science would try to achieve an honest understanding of the results of science and would not, a prey to prejudice, blame science for each and every misfortune of our age. In this context I should like to mention the idea expressed in a memorandum of the Faculty of Science of the Munich University on the Draft Agreement:

'It is one of the immortal achievements of Greek culture to have recognized the importance of thought for the understanding of the universe and the mastering of life. But it was left to our modern age to discover that thought must surrender when it is contrary to the divine order. The realization of this fact must be considered the unique intellectual contribution of our age and ranks on an equal footing with that of antiquity.'

Perhaps we shall have to find other ways of coming to an understanding of the purport and value of science for our thoughts and actions, thus gaining the broad foundation needed for the future. Here the thought adumbrated in the Munich memorandum may be an important aid. It can be of considerable value for the 'studium generale' in the upper classes of our gymnasia, and it can give a new impetus to science teaching. Let us hope that we shall not be frustrated in these endeavours by untimely edicts, but will be helped by the ready understanding of these matters that one finds abroad.

Pin-pointing the Prehistoric

Arie De Kool

ONE of the greatest Dutch scientists of the last half century was Professor Hessel L. de Vries, senior lecturer at Groningen University. Prof de Vries (1916-1959) carried out pioneering work in many fields but his research into the determination of age in geological and archaeological objects with the aid of radioactive elements—particularly carbon 14—was probably the most important for international science

Professor Hessel de Vries

In 1949 the American scientist Libby—who was awarded the Nobel Prize in 1960—reached the conclusion that it ought to be possible to employ slow-changing carbon in finding out just how old archaeological objects were.

Nitrogen in the atmosphere—which is also found at higher altitudes—changes into carbon under the influence of cosmic radiation. The resulting product is not carbon of the normal type—which is referred to by the number 12—but a new type known as carbon 14, a designation reflecting the number of particles in the nucleus of the atoms in the material.

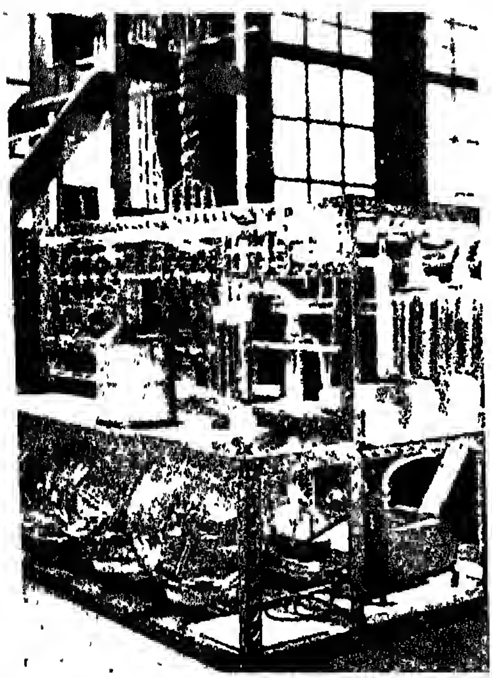
Carbon 14 is not a stable matter, the nuclei of the atoms are overloaded with particles and after a time their structure changes and the carbon reverts to nitrogen. This is not, however, a rapid change; it takes 5570 years for half the carbon to revert and after a further 5570 another one-quarter undergoes the change, and so on.

Libby was the first to publicise the fact that nature provides for a balance in the upper layers between the amount of carbon 14 created and the amount which reverts to nitrogen. Plants absorb carbon from the atmosphere to help in their growth process, and this can be either carbon 12 or carbon 14 since, chemically speaking—e.g., in terms of nutritional value—there is no difference.

But when a plant dies, it ceases to consume carbon, and no fresh carbon 14 is added On the contrary, it continues to decrease at the rate of 50 per cent

Reprinted from a tape recording of a talk on Radio Netherlands. By Courtesy of the Royal Netherlands Embassy, New Delhi.

in 5570 years. Libby built highly sensitive apparatus with which he measured the radioactive radiation. There is little carbon 14 in existence and it has a low degree of radiation. Libby then drew a comparison between the radioactivity of a piece of new wood from the University gardens and compared it with that of an old book or an ancient spear. By this



Thermal diffusion columns in which samples with a small concentration of carbon 14 are enriched.

method he could determine the respective ages of the objects within fairly close limits. The comparison was only 'fairly close' and the method applied only as long as the object was not too old; the reversion of carbon 14 into nitrogen caused a drop in the radioactivity and once this point was reached, Libby's method could not produce any more information than archaeologists obtain otherwise.

The idea which turned carbon 14 into an inestimably valuable aid to science came from Prof. de Vries. Counters were built in Groningen, and by using very careful experimental techniques he succeeded in determining ages up to a maximum of 50,000 years; the limit being set by the decreasing activity in proportion to the age of the object. There are always a number of counts, known as the 'background' (something akin to the background hiss on an unused magnetic tape) due in this case to cosmic rays and rays from radioactive impurities in the objects under observation. When the activity of the sample equals this 'background', the limit of measurement has been reached.

By a method developed in the F.O.M. Laboratory for Mass Spectography, it is possible, however, to enrich the low carbon 14-activity.

The carbon is oxidized to form the gaseous compound CO, carbon monoxide. It is then brought into a thermal diffusion column. Such a column consists of a glass tube about 4 metres long with a central, electrically heated wire and a water-cooled wall. In a thermal diffusion column gases of different molecular weight are separated, at the top the concentration of the light molecules is increased, and at the bottom the concentration of the heavy molecules. In this way enrichment of the carbon 14-concentration by a factor of 16 is possible; this takes about two months. This method extends the limit of 50,000 years to about 70,000 years, as, by enrichment of 2^n, the limit of counting is extended by n half-lives; $16=2^4$ and the half-life is about 5600 years, so the extension is 4×5600 or about 22,000 years. (By 'life' is meant the period of time in which radioactivity decreases to nil).

The exact value of the enrichment factor of the thermal diffusion column is determined by also adding a given amount of oxygen 18 to a compound of carbon monoxide.

We then have carbon 12 oxygen 16 with mass 28
carbon 14 oxygen 16 with mass 30
carbon 12 oxygen 18 with mass 30

The enrichment of oxygen 18 can be determined by analytical, i.e. mass-spectrometrical means and from this the enrichment of carbon 14 can be computed.

The amounts involved in all this are microscopic. In new timber, the amount of carbon 14 is no more than three particles per ten billion. A piece of wood 10,000 years old contains one particle of carbon 14 per 13 billion and a piece 70,000 years old (the limit reached by Prof. de Vries) has only one particle per 13,000,000,000,000,000. In other words, in order to obtain one gramme of carbon 14 it would be necessary to have 13,000 million tons of this material. Normally availability does not exceed a few grammes, at the most one kilogramme. Skeletons of Neanderthal men, for example, contain a much lower concentration of the element than, say, a piece of charcoal, thus all similar skeletons discovered so far would, together, fail to provide one-millionth of a gramme of it. Nevertheless the method has resulted in some remarkable discoveries in the geological and archaeological fields. With it, it was fairly simple to establish that in both Europe and North America an Ice Age occurred some 18,000 years ago which put an end to all forms of life. It was accompanied by the movement of glaciers which completely destroyed the woods, which were themselves slowly deteriorating The trees which were pressed into the soil by the weight of ice are still there, and with the aid of carbon 14 it is a relatively simple task to put a date on them.

Research has shown that better times followed in Europe a few thousand years later—about 12,000 years ago. The ice must have moved on because vegetation recommenced. The type of plants which grew can be recognised from the pollen grains which have remained preserved, and once again it was carbon 14 which helped to establish the period in which the plants grew

Thanks to improved methods, it is also possible to recognise really archaic remains, for example those which show that the Neanderthalers arrived in Europe about 80,000 years ago and that they left again—or became extinct when the climatic conditions changed appreciably about 20,000 years later. They were followed by the Cro-Magnon race, and the development of culture among these human beings has been established practically year by year with the aid of carbon 14.

The rise and fall in the level of the oceans, accompanied by changes in climatic conditions and movements of the Earth's crust have also been accurately pinpointed with the aid of the same method. With this method of research, practically the whole history of the human race and the earth on which they lived and live has been unravelled

No sooner did the work on carbon 14 produce astonishing results than work was started with other elements like

uranium which changes to lead and with [illegible] of which two types exist, the one [illegible] more frequently in higher temperatures, the other being preferred where the climate is colder. All this work, now almost done on a routine basis, is possible through the break-through initiated by Prof. de Vries. He was in the middle of a fresh project which, later, led others to great results) when, in 1959, he died under very tragic circumstances.

Young folks corner

Scientists You Should Know

JAYANT VISHNU NARLIKAR

YOUNG Narlikar, an Indian mathematician, now in Cambridge hit the headlines recently when he presented a paper with Prof. Fred Hoyle on a new theory of gravity to the Royal Society in London.

The new theory evolved by Narlikar and Hoyle is an improvement on the Einstein theory of general relativity. Einstein's theory has dominated science for the past five decades, and the new modification of Narlikar and Hoyle has already attracted world-wide attention.

According to Einstein, matter behaves as it does because of the properties of space and time. According to the new theory, gravity is something belonging to matter. If all the matter was removed gravity would also cease to exist. In other words, gravity depends on the density of matter in the universe. Hoyle's new theory is based on the fact that the mass of every object in the universe is affected by its interaction with every other object. The new theory also explains why gravity is always a force of attraction and never of repulsion. Hoyle's theory also explains why galaxies in distant parts of the universe can, theoretically move away from the earth faster than the speed of light—a limit that Einstein said could not be exceeded.

Young Narlikar at School

The most striking consequence of Hoyle-Narlikar gravitation is that it explains how the mass of every particle in the universe helps to create the mass of every other particle. A universe with

nothing as it is impossible. There must be atleast two particles each to give mass to the other. Mass is that property of a body which resists change of motion. On the surface of the earth it is equivalent to weight.

Jayant Vishnu Narlikar

Jayant Vishnu Narlikar was born on July 19, 1938 at Kolhapur. After taking his B.Sc. degree from the Banaras Hindu University where his father was Professor of Mathematics, Narlikar went to Cambridge. He passed Mathematical Tripos with distinction in 1960 and obtained the doctorate in 1963 from the Cambridge University. Throughout his academic career he was the recipient of many prizes and scholarships among which may be mentioned the 1912 Exhibition Scholarship at Fitzwilliam House and W.A. Meek Scholarship. He was elected Fellow of the Royal Astronomical Society in 1963 and was appointed as Research Assistant to Professor Hoyle from February 1963. He has attended several International Conferences of which may be mentioned the Relativity Conference in Vienna and the World Astronomical Conference in Greenwich. He has published several research papers and has addressed academic bodies and participated in seminars, etc. Last May 1964 Jayant Narlikar addressed the British Society for the Philosophy of Science on, 'The Arrow of Time.'

On June 11, 1964, he and Prof. Hoyle addressed the Royal Society on the subject of their new theory of gravitation, half an hour each. At the end of their talks there was lively discussion. His latest paper on, 'A New look at Gravitation' in *New Scientist* (June 27, 1964) may be read with interest. (Reprinted elsewhere in this issue).

Jayant had never to work very hard for his examinations. According to his father the only examination in which he failed—and he failed twice before being successful—was the driving test for a motor driver's license at Cambridge. He has a taste for photography and music (both Eastern and Western). He was an outstanding badminton player on the Banaras Hindu University Campus during 1950-52. He has read many classics in Marathi, Hindi and English. He is a lover of the works of A.A. Milne, W.W. Jacobs, P.G. Wodehouse and Conan Doyle.

Narlikar has done it and it is quite possible that many of our young readers can one day become great scientists.

S. DORAISWAMI

Test Your Knowledge

What is the 'Red Tide'?

Sometimes vast expanses of the ocean are coloured red producing 'red tide' or 'red water'. This phenomenon is very common in the Gulf of Mexico at certain seasons. It has also been reported on other coasts from Japan to Africa and California The red tide is due to the presence of large numbers of the unicellular dinoflagellate, *Gymnodinium brevis* or some other similar organism like *Gonyaulax*. Sometimes *Noctiluca* becomes abundant These outbreaks of 'red tide' often cause the death of fish and other living organisms. In 1946-47, it was reported that nearly 200 million lb of fish were dead due to the red tide. The organisms multiply repeatedly and rapidly forming an algal 'bloom'. Fish swimming into the area are partly paralyzed and turn over on their backs and die The algae produce a poison that affects the nerves of the fish. The Red Sea derived its name, paradoxically, from the occurrence of water blooms of a blue-green alga, *Trichodesmium erythraeum*.

S.D.

What is homeostasis?

Homeostasis is the capacity of living things to maintain constant or nearly constant internal conditions, in spite of changes in the internal and external environments. All our reflex actions are rapid responses to or expressions of this mechanism. Adaptation to environmental condition is one of the slower reactions of homeostatic nature. Water diffuses into the cell of *Paramecium*. The contractile vacuoles pump it out again. The concentration of water in the cell is kept constant. This is an instance of the principle of homeostasis. S.D.

Can earthquake be predicted?

The actual moment of their happening cannot be predicted. But scientists can guess pretty accurately their next point of attack, along an active fault. At present it is not possible to say just when and where and how violently an earthquake will occur. But some scientists are of the opinion that a way to predict earthquakes in future is possible by tuning in on the sounds rocks make when they are under great stress. The rocks make some sounds before they rupture and this can be used as a diagnostic tool. A geophone, a sensitive instrument to detect vibrations would be buried one or two thousand feet deep near an earthquake fault, usually in a zone of weakness It would be used to detect sounds, and continuous record made on a tape at the surface.

The system has not been tried yet. The equipment and installation would cost about a third of a million dollars. S.D.

Why does the Moon seem to follow us when we are moving?

The great distance between the Earth and all objects in space, including the Moon, makes it necessary for us to traverse great distances on the face of the Earth in order to change our viewpoint of the Moon. We can alter our viewpoint of anything upon the Earth by a very minor change of our position. Hence, as we watch the Moon while we are travelling over the surface of the Earth, the Moon seems to stand still, while local landmarks appear to approach us, pass us and recede into the distance behind us. The illusion thus created is that the Moon is moving in the same direction as we are.

What is 'pigeon milk'?

Degeneration of the cells which line the crop produces in pigeons (and some species

of parrots; a thick, cheese-like secretion called 'pigeon milk'. On this the young bird are fed until they are old enough to eat the seed diet of the adults.

Does only the female pigeon produce the 'milk'?

Both the male and female produce the milk during the breeding season. It is extremely rich, containing about [illegible] per cent fat. The milk of most cows seldom has more than [illegible] per cent fat content.

What makes a pearl?

A pearl is made of the same substance as the inner or 'mother-of-pearl' lining of the shell, and both shell and pearl are produced by the living mantle tissue. Any small nucleus such as a grain of sand or the egg or larva of a parasite may serve as a centre around which pearl substance may be found. Layer after layer is applied around the irritating object by the surrounding living tissue so that a round bead generally builds up, the lustre of which is due to the concentric layers of the crystalline pearly substance. The parasite which most frequently causes pearl formation in the Ceylon pearl oyster is the early stage of a tapeworm which becomes adult in a large ray which habitually feeds on these oysters, thereby infecting itself with the tapeworm. After becoming mature, the tapeworm lays eggs which pass into the sea where they may find a temporary home shortly after, but a grave if the oyster should be provoked to protect itself from the irritating parasite by coating it with pearly substance. It may be that pearls are also formed around tiny granules of waste matter produced by the oysters themselves.

Science notes

A WORLD COMMUNICATIONS SYSTEM

BALLOONS, 'anchored' about five kilometres above the earth's surface, could form the links in a world communications system using lasers (devices producing narrow beams of intense light with properties similar to those of radio waves). The idea is put forward in a paper being presented to the international conference on lasers and their applications, which opened in London yesterday (September 29), by Dr A K. Karbowiak, a scientist with Standard Telecommunication Laboratories Ltd., of Enfield, Middlesex

Dr. Karbowiak's scheme would overcome one of the difficulties in laser communications—interference with light beams by weather conditions.

Laser light beams are highly directional and can be aimed very accurately at receivers. As they possess enormous capacity as communication channels, they are the object of intense research in many countries.

The earth's atmosphere has many variable and unpredictable properties which affect light beamed from point to point. The atmoshere is opaque to large parts of the light spectrum available from lasers, and even the 'windows' would be seriously affected by the shimmer of hot air in the summer, for example, and would be blacked out completely in bad weather.

Short distances could be spanned by an 'open' laser system if full reliability was not paramount, but for any other job the laser light would have to be 'piped' down evacuated tubes or perhaps along glass-fibre cables For this reason both methods are being investigated.

Series of Balloons

Dr. Karbowiak's suggested scheme would remove the lasers from interference completely. He envisages a series of balloons tethered at a height of about five kilometres and about 200 kilometres apart Each balloon would carry a transmitter and receiver, powered either by a power-pack or through a cable from the ground According to Dr Karbowiak, the communication links with the ground (which could not be by laser beam) could be a series of microwave radio links or, if future development makes it possible, a cable capable of carrying the light signals.

It would be a simple job to keep microwave equipment aligned between the balloon and the ground because its position would be known accurately even if it were invisible from the ground station. It would also be comparatively easy to keep the laser beams on target by installing tracker equipment to allow for swinging of the balloons in any direction Such movements would be very slight at the tethering height of five kilometres

Dr. Karbowiak says that such a system would be cheaper than satellite communications, and tracking problems would be far easier. Its reliability would be a particular advantage

A balloon system of this sort is techno-logically possible, though there are still many difficulties to overcome. Its exact cost is impossible to estimate, but in general, the larger the demand for channels, the greater the chances of complex systems being a paying proposition. As demand is growing rapidly, Dr. Karbowiak thinks that optical communications systems can well prove to be economically attractive, although the realization of such a system is many years away.

EXCITING POSSIBILITIES

In his opening address to the conference, Sir Robert Cockburn, chief scientist of Britain's Ministry of Aviation, said that the first practical lasers were only demonstrated in 1960, and their practical applications had been somewhat limited in relation to their potential.

However, there were exciting possibilities, including improved short-range radar devices and new techniques of airborne surveillance and of guidance and control for weapons and aircraft.

The laser had already provided physicists with a powerful new tool, particularly in spectroscopy, where it should reveal a wealth of new data about the molecular structure of matter and lead to new methods of examining and exploiting atomic structures

By Courtesy : British Information Services, New Delhi.

NOBEL PRIZE FOR CHEMISTRY, 1964

The 1964 Nobel Prize for chemistry was yesterday (October 29) awarded to Professor Dorothy Crowfoot-Hodgkin of Somerville College, Oxford, 'for her determinations by X-ray techniques of the structures of important biochemical substances'

Prof. Crowfoot-Hodgkin (54) is Wolfson Research Professor of the Royal Society and a Fellow of Somerville College.

The Royal Swedish Academy of Sciences said that Prof. Crowfoot-Hodgkin 'has shown exceptional skill, in which chemical knowledge, intuition, imagination and perseverance had been conspicuous.

"The majority of the substances which Mrs. Crowfoot-Hodgkin has studied are of considerable significance for biochemistry and medicine, but two of them are worthy of particular mention in view of both the difficulty of the problem and the value of the result. These are penicillin and vitamin B-12'.

Prof. Crowfoot-Hodgkin is only the third woman to win the Nobel Prize for chemistry in the 63 years' history of the award. The others were Marie Curie (1911) and her daughter Irene Joliot-Curie (1935).

By Courtesy : British Information Services, New Delhi

U.S. SCIENTISTS SUPPORT THEORY THAT LIFE CAME FROM SEA

Scientists often have theorized that life first appeared on earth in the oceans, but they have been able to produce little evidence to prove it.

The theory is that the incessant tossing of the ocean churned non-living inorganic particles during millions and millions of years to form complex organic matter and that finally the first one-celled living organisms evolved.

Now, four U.S. oceanographers report evidence that the ocean does in fact create larger and more complex organic matter out of simple organic particles, lending support to one chain of the theory.

They said individual organic particles grow into larger clumps by sticking to air

bubbles formed by the constant motion of waves The bubbles are a sort of handle to which the particles cling.

Doctors Gordon Riley and P. J. Wangersky of Yale University and E.R. Baylor and W.H. Sutchliffe of Woods-Hole (Massachusetts) Oceanographic Institute reported their work through the National Science Foundation, which financed their research.

They demonstrated in the laboratory that bubbling sea water attracts and holds organic particles in colonies. Examination of actual organic matter from the sea showed it was clumped together in the same way

The scientists reason further that the clumps are the main food supply for the ocean's tiniest marine life, which, in turn, are the basic food supply for all higher marine life.

There is an estimated five times as much of this organic matter by weight in the oceans as there is animal life.

Tiny ocean plant life known as phytoplankton, previously thought to be the sole food supply for the tiniest marine life, is not present in sufficient quantity to feed them.

Until now, oceanographers thought that the marine food chain was a one-way process in which life was derived from life. Organic matter had to decompose into inorganic chemicals before it could be assimilated by phytoplankton plants and converted to living matter.

Dr. Riley said the long-held belief was untenable. Phytoplankton, he pointed out, grow only near the surface of the ocean and become very scarce in winter when less sunlight reaches them. Ocean surveys indicate that the amount of phytoplankton present during the winter months could not possibly support the abundant marine animal life.

Also, he said, the tiny marine animal life grow and multiply in deep dark waters beyond the depth where the plants exist. Therefore, he said, there must be another basic food supply in the ocean.

WORLD'S LARGEST X-RAY PHOTOGRAPH ON DISPLAY AT NEW YORK WORLD'S FAIR

The world's largest radiograph—which is the proper name for 'X-Ray'—is on display at the New York World's Fair, showing an entire jet engine with all its inner parts.

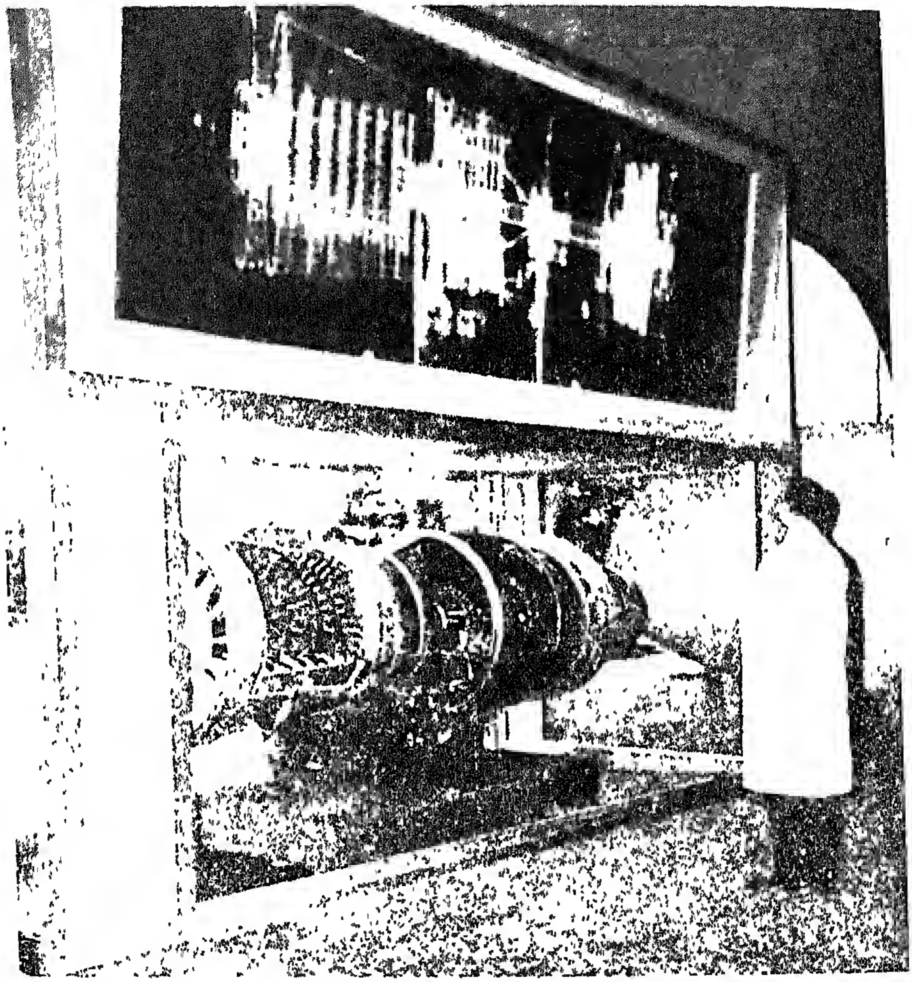
Until now, the world's largest radiograph showed an American jeep. That picture has been on display for several years at Eastman House, a photographic museum in Rochester, New York.

The new title holder is 16 feet 8 inches (5 metres) long and 5 feet 9.5 inches (1.74 metres) high. It shows the engine that is used to power large, long-distance passenger aeroplanes such as the Boeing 707 and Douglas DC-8.

The engine parts and their relationship, clearly visible in the radiograph, cannot be seen any other way except by dismantling the engine, which would involve destroying some of its components. The huge engine is on display at the Fair below the radiograph.

The exhibit illustrates modern methods of testing materials and machines without taking them apart or destroying them, a technique which engineers call 'non-destructive testing.'

This industrial use of radiography is similar to its use in medicine for diagnosis. Through radiography, physicians can



World's largest radiograph of a jet engine. The engine is shown below in the lower picture.

look deep inside the human body and detect abnormalities and disease often long before the patient is aware of any trouble. In many cases, the only other way for a similar examination is surgery.

The unusual radiograph, on display at the Eastman Kodak pavilion at the Fair, was made with conventional basic X-ray techniques. However, very large equipment had to be used, and various technical difficulties overcome.

The exposure was made with a two-million volt X-ray camera in the unusually large X-ray of the Foster-Wheeler Corporation, manufacturers of heavy machinery, at Mountain Top, Pennsylvania. Technicians placed overlapping strips of film 50 feet (15 metres) from their camera and then placed the engine between camera and film so that the engine's axis was 57 inches (1 45 metres) from the film. Distance from

camera to engine was 41 feet 6 inches (12.5 metres).

This distance from camera to engine was necessary to cover the engine's full length with one exposure.

However, test exposures revealed that because of the distance radiation was scattered along the floor, spoiling the lower part of the film. To minimize this scatter, a plate of lead one inch (2.5 centimetres) thick was used to cover the lower half of the outlet of the X-ray tube, which was completely covered by a quarter-inch (six millimetre) lead filter. The engine itself caused X-ray scatter, but this was minimized by a curtain of lead-oxide-coated paper over the film.

The technicians packed seven layers of film strips, each strip measuring 8 feet by 4 inches (2.4 by 0.35 metres), in light-tight packages. Seventeen such packages were mounted vertically, with one-inch overlap, on a sheet of plywood, backed by lead shields.

During the one-hour exposure the top three layers of the seven-layer strips in each packet served as soft-radiation filters. The four rear layers then recorded excellent images of the jet engine. After being developed the filmstrips were joined to produce the large radiograph.

By courtesy: U.S.I.S., New Delhi

NEW CAMERA TELESCOPE WILL PHOTOGRAPH INTERIOR OF EYE

An instrument which will permit exploratory photography of the ciliary body of the eye has been designed by the chief medical photographer Mr. Ronald Plummer, at the Sir Charles Gairdner Hospital in Perth, capital of Western Australia.

The instrument consists, briefly, of a camera attached to an endoscopic reflex housing manufactured as a stock item by Leitz of Wetzler, West Germany. The camera, although a stock model, must for obvious reasons be equipped for automatic winding of the film.

Mr. Plummer modified the camera to fit the housing, and devised the intra-ocular telescope for insertion into the eye-ball. Camera and telescope can be hooked up in one second.

The telescope is 4 in long and 4 mm in diameter, and has for oblique vision. It is inserted into a 4 mm stainless steel sheath having at its extremity a specially wound electric globe. Activated by wet-cell batteries, the bulb views at $4\frac{1}{2}$ volts. At the moment of photographing, it over-volts to 9 volts, providing sufficient light inside the eye for colour or black and white film.

In operation, a suture is put in position on the outer wall of the eye-ball, a cut is made in the suture opening, the sheath enclosing the telescope is inserted, and the suture is tightened around it to prevent leakage of the intra-ocular fluid.

The instrument is then in position for either photography of the inner surface of the eye, or, if no photography is intended, for inspection through the telescope.

Although his intra-ocular telescope was extremely well received when presented at the Australian Opthalmology Congress held in Perth in September, Mr. Plummer does not regard it as the ultimate design for this purpose.

'The principal fault at this stage is the instrument's size,' he said. 'It is necessary to make a 5 mm incision in the eyeball to introduce the sheath.

'One should suggest, at the moment, that it will be used only in extreme cases,

to explore the possibilities of [illegible] an eye, rather than to [illegible] the nature of the ciliary body, for which it was originally conceived.

'However modification will be suggested by eye surgeons who will use it, and in time we will come up with something better — a smaller, more refined instrument is the aim'.

By Courtesy: Australian High Commission, New Delhi

INDIA AND BRITAIN SHARE LOSS OF DISTINGUISHED SCIENTIST

In the death of Dr. J.B.S. Haldane, F.R.S., India has lost one of her most brilliant and distinguished scientists. This sense of loss is shared by Britain because before he became an Indian citizen he was outstanding among British scientists.

John Burdon Sanderson Haldane, the son of Dr. J.S. Haldane, F.R.S., himself a distinguished physiologist, was born in 1892 and was educated at Eton and New College, Oxford. He was successively Reader in Biochemistry at Cambridge University, Professor of Physiology at the Royal Institution, and Professor of Genetics, and later of Biometry, at London University.

In 1957 Dr. Haldane came to live in India and applied for Indian citizenship, which he received in due course. He took up the post of Research Professor at the Indian Statistical Institute, Calcutta, where he remained until 1961. After a short period under the Council of Scientific and Industrial Research, he went to Bhubaneswar to take charge of the new Genetics and Biometry Laboratory set up by the Orissa Government.

In 1963 he underwent a major operation, and wrote — very typically — some gallantly humorous verse about it called 'Cancer's a Funny Thing'. After the operation he returned to Bhubaneswar and continued his work there until the time of his death.

Dr. Haldane served throughout the first World War in France and Iraq. During World War II he and his wife, Dr. Helen Spurway, herself a distinguished biologist, worked on the physiological effects of high pressure and decompression on submarine crews, experimenting on themselves at no small risk. Dr. Haldane was always a great man for experimenting on himself. In his essay 'On Being Your Own Rabbit', published many years ago, he described some of his experiences in this line.

He wrote many books of great interest which reached the expert and man in the street alike. He was one of those men of genius who could come down to the level of the common man and make really abstruse things comprehensible and exciting.

One of the greatest things about Dr. Haldane was the interest he took in his junior colleagues, his inspiration and encouragement of them, and the way he invariably gave them credit for the work which they had done. Indeed, a sure way to annoy him was to attribute to him the work of one of his colleagues.

By Courtesy: British Information Service, New Delhi.

New trends in science education

Summer Institute Programme

A NEW APPROACH IN THE TEACHING OF CHEMISTRY

N.K. Shrimali
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WE are passing through a state of fermentation regarding science teaching in our schools. Every science teacher feels that the present syllabi, textbooks, examination system and the methods of teaching need drastic change. Science teaching should not be mere imparting of scientific information and its memorisation by the students, and practical work is not mere verification of scientific facts. Evaluation should not continue to test their power of reproduction on the basis of rote memory. No doubt, the present system certainly develops certain skills in the students through prescribed practicals such as identification of acid and basic radicals, determination of strength of solutions through titrations, detection of certain elements in organic compounds, gravimetric estimation, etc.

Chemistry teaching in secondary schools should not have only a limited aim in developing only certain skills and imparting knowledge of some scientific facts. We have to prepare our students as intelligent citizens of an emerging industrial society. The students should be trained to appreciate and understand intelligently the implications, social and economic, of the modern inventions. The science teacher of today will therefore have to accept the challenge to train his students in such a way that he imbibes the scientific spirit of keen observation and experimentation. They are to be trained to acquire the habit of questioning, develop skills of proper manipulation and utilization of available scientific data and learn methods of investigation, building hypotheses and testing them, etc.

The Summer Institute programme organized during the last two summers is an attempt to examine and eventually evolve a new approach in science teaching, and it is expected it will have its deep impact in the field of science teaching. I had the privilege of joining the Summer

Institute in Chemistry [illegible] School teachers [illegible] at the University of Rajasthan, Jaipur [illegible].

It is now widely agreed [illegible] conditions in our country [illegible] that unless the present science textbooks and the examination system are changed science teachers cannot [illegible] approach. The participants of the Summer Institute in Chemistry at Jaipur during their course examined the possibilities of utilizing the CHEM-Study material in our present set up. We concluded that the usefulness of the new approach 'Chemistry: An Experimental Science' was beyond doubt. Even within the limitations imposed by equipment in laboratories, budgets, timetable, prescribed courses and textbooks etc., some of the CHEM-Study material has practical application. The Director's report of the Summer Institute (see extracts at the end) contains practical suggestions as to how and to what extent experiments in the Laboratory Manual can be included in practical work by our students. It also suggests some of the experiments that science teachers can profitably use to improve lecture demonstrations in the classrooms. It further includes suggestions to make practical use of the CHEM-Study textbook chapters or articles therein in developing theoretical concepts. In addition to that it recommends that films prepared under the CHEM-Study material can be profitably used in our schools if dubbed in Hindi. Also some of the new concepts such as molar concentration, uncertainty factor in measurements, energy effects in chemical reactions, oxidation number, etc., should also be introduced at the school level.

The CHEM-Study material consists of a text book, laboratory manual, teachers' guide* and some related films. The approach is summed up in the title under which all the literature is produced viz. 'Chemistry: An Experimental Science'. It is a laboratory-centred course. Student's laboratory work and his first hand observations are the basis on which the whole structure is built. It provides unique opportunities to students to have the excitement of discovery through experimentation.

The laboratory manual is so written that each experiment first raises a problem and then lays down instructions providing a general framework for experimentation. It follows heuristic approach so that the student often gets the joy and thrill of discovery. There is emphasis on careful observations and recording them in a systematic way. This will generally follow the teacher's demonstration related to the topic. Then there is classroom discussion on the basis of observations and first hand experiences to make deduction or to discern regularities. Also related films provide experimental evidence needed to develop a principle or enunciate a theory. The films provide opportunities to students to see demonstration of experiments under conditions not usually available in school laboratories. As the experiments are performed questions are raised to stimulate thinking, and steps are suggested to make calculations on the basis of quantitative measurements. The Teachers' Guide Book contains 'quiz' questions to provide new situations in which the evolved concepts and principles will have to be applied. The Teachers' Guide contains very helpful material for teachers

* All these three books have now been reprinted by the NCERT and are available at low cost.

in the remote parts of the country where the facilities of library and equipment may not be satisfactory. At the same time the course in no way denies the energetic and resourceful teacher of his initiative and ingenuity. This is in short the CHEM-Study material with reference to the new approach.

The Chem-Study material and course cannot be used as they are in our country due to several reasons such as difference in standards achieved at the end of VIII grade, equipment in laboratories, medium of instruction, etc. But the spirit underlying the approach can surely be imbibed. We can adapt this material wherever necessary to suit our conditions and resources. Here are one or two examples to illustrate this point.

Before I attended the Summer Institute I have been assigning to class IX students some experiments (as stated below) during the first week of the opening of the school. Each student was supplied with a few test-tubes, a burner and a little of the substance to be examined one after another.

Assignment—Examine the following substances under the heads shown below and note down your observations.

Common salt, sal-ammoniac, blue vitriol, green vitriol, chalk (or marble), sulphur and red oxide of mercury

Substance examined... .. ..

Experiment	*Observations*	*Inference*
1. By seeing (colour power of transmission etc.)		
2. By smelling		
3. By touch		
4. By hammering		
5. By putting in water		
6. By heating		
7 (special experiments as suggested see note below)		

Note: Under experiment 7 each substance was to be given different treatment as for example

Common salt: Mix a solution of this drop by drop with 5 ml of silver nitrate solution. Place the test-tube in sunlight and carefully record the changes.

Sal-ammoniac: (1) Heat strongly about 2 g of sal-ammoniae in a dry test-tube. (2) Mix about equal amounts of sal-ammoniac and caustic soda and smell the mixture.

What is the smell like?

Blue vitriol: (1) After cooling the test-tube in experiment 6 with blue vitriol add 3 or 4 drops of water to the powder. Note the change.

(2) To a solution of blue vitriol add a few pieces of iron (first clean them with sand-paper). Keep for 10-15 minutes, observe the change in the colour of the solution. Examine the surface of the iron pieces. How do you account for the change in the colour of the solution and deposition on the surface of the iron pieces ?

Green vitriol: (1) Heat it strongly. Test the [illegible] drops deposited on the upper part of the test-tube with blue litmus paper. Test [illegible] solution and dilute sulphuric acid also with litmus paper separately.

(2) Add potassium ferrocyanide solution to a solution of green vitriol. What does the mixture look like?

Chalk or marble: To about 2 g of marble pieces or chalk in a test-tube add drop by drop about 2 ml of dilute hydrochloric acid. Record the observations.

Sulphur: (1) Heat it strongly until it boils. Pour the boiling sulphur in a beaker full of water. How does water-cooled sulphur differ from the original sulphur powder?

(2) Take about 0.5 g of powdered sulphur in a test-tube. Add about 2 ml of carbon disulphide and shake the test-tube vigorously. What conclusion do you draw from your observations?

Red oxide of mercury: Heat strongly about 3 g of red oxide of mercury in a large test-tube. Bring a glowing splinter of wood in the test-tube from time to time while continuously heating the test-tube over a burner.

Cool the tube. Take out the remaining powder. Scratch the sides of the test-tube with a splinter. Examine carefully the scratched material collected at the bottom of the test-tube.

The students examined two substances in a period. Next day the period was utilized to discuss their observations and draw inferences. Many properties such as brittleness, opacity, transparency solubility, water of crystallization, etc were discussed on the basis of their direct observations.

Thus I found to my great satisfaction that I was following, in a vague form and in a limited sphere, identically the new approach. After the Summer Institute experience I have tried to apply the new approach in the teaching of equivalent weight to class X during this session. The method might interest my fellow teachers.

Experiment. Combining ratio of magnesium and oxygen. Intorduction—(20 minutes) From the students' previous knowledge it was elicited that in the formation of water 1g of hydrogen combines with 8 g of oxygen to produce 9 g of water. Similarly, in hydrogen chloride 1g of hydrogen combines with 35.5 g of chlorine to form 36.5 g of hydrogen chloride. Thus different elements combine in different ratios by weight with each other. The students had already studied oxides and therefore they knew that magnesium combines with oxygen to form magnesium oxide.

Laboratory period—1 hour and 20 minutes.

The experiment was then planned with the help of students to find out the combining weights of magnesium and oxygen. Necessary precautions were given. They were cautioned to raise the lid of the crucible carefully while heating magnesium to allow fresh air to enter the crucible.

Each student was then supplied the necessary material to find the combining ratios of magnesium and oxygen. They

were asked to make the following observations and calculations.

Weight of the crucible
,, ,, + magnesium =
,, ,, + magnesium oxide

Weight of magnesium
,, ,, magnesium oxide
,, ,, oxygen which combined with magnesium

— g of oxygen combined with g of magnesium.

8g of oxygen combined with -g of magnesium.

Note :

1. Each student was given magnesium pieces about 0.2 0 3g.
2. They were asked to assure complete burning of magnesium by heating, cooling and weighing the crucible repeatedly until a constant weight was obtained.
3. Students' results varied from 9 to 10, but with a little more practice they could do better.

Next day the teacher's demonstration was arranged. Time 40 minutes.

A quantity of about 0.15 g of magnesium pieces were placed in about 3 ml of water at the bottom of a conical flask. A test-tube placed inclined in the flask contained about 3 ml of concentrated hydrochloric acid The flask was then carefully tilted to mix the acid with water. Hydrogen evolved was collected in the graduated cylinder. The volume of hydrogen evolved was measured adjusting the level of water inside and outside the graduated cylinder the same. Also room temperature, atmospheric pressure and aqueous pressure were noted. The weight of magnesium required to displace 1 g of hydrogen from hydrochloric acid was then calculated the next day. Then the definition of equivalent weight was evolved with the help of students. Thus the concept of equivalent weight was built on the basis of observations and calculations on students' experimental data and teacher's demonstration findings.

It is suggested that the following experiment can also be entrusted to individual students. I have tried it. It comes out satisfactorily.

Experiment. Displacement of one metal with another.

Procedure. Dissolve 5 g of copper sulphate in 150 ml of water in a 250 ml beaker. Take a magnesium ribbon about 1 5g in weight. Clean it with sand paper. Then weigh it accurately in a physical balance. Then coil about two thirds of it and suspend it with the help of a glass rod put across the beaker taking care that the coiled portion remains dipped in the solution.

Carefully record all observations for fifteen minutes :

Leave the beaker over-night covered with a watch glass.

Next day examine the beaker without disturbing it.

What is the colour of the solution?

What is the deposition at the bottom of the beaker?

Take out the magnesium ribbons or pieces of magnesium, if any. Wash them in the same beaker to remove copper particles. Dry them and weigh them carefully with the same balance.

Decant water from the beaker. Wash copper particles with fresh water twice and decant.

Dry the copper particles with the beaker on a sand bath. Weigh the beaker with the copper particles.

Put a few drops of concentrated nitric acid on the copper particles to test copper. Record your observations.

Clean the beaker, dry it and weigh it.

Make calculations as follows:

Weight of the magnesium ribbon left over after it had reacted with copper sulphate solution=

Weight of magnesium dissolved

Weight of copper dust+beaker —

Weight of the beaker =

Weight of copper deposited .

(The displacement takes place in the ratio of the equivalent weights of the metals).

$$\frac{\text{Equivalent weight of copper}}{\text{Equivalent weight of magnesium}} = \frac{\text{Weight of copper deposited}}{\text{Weight of magnesium dissolved}}$$

Note: Your teacher will tell you the equivalent weight of either copper or magnesium. Calculate the equivalent weight of the other metal.

Thus the new approach can be summarised briefly as preliminary introduction by a teacher for motivation or posing a problem. The students should then get an opportunity to work and conduct experiment in the laboratory. Carefully planned Laboratory Manual will guide him in his laboratory work. This will be followed by teacher's demonstration wherever necessary. Related films can also be shown. The students' first hand observations during laboratory hours, class-room demonstration and film projection will form the base to build up concepts and understanding. For intelligent laboratory work the urgent need is to make available carefully prepared laboratory manuals by experienced teachers and professors. Some agency will have to take up this work to get laboratory manuals covering the entire secondary and higher secondary courses prepared

Until the laboratory manuals or suitable textbooks for the new approach are prepared chemistry teachers can certainly do something on their own initiative on the lines suggested above. Truly speaking laboratory manuals and textbooks to suit the new approach should evolve out of experiments conducted by enthusiastic teachers in their respective schools. For successful application of this new approach it is not so much a question of expenses, (of course it needs a slightly better equipped laboratory and some additional expenses) as willingness on the part of a teacher to do more work, prepare better and above all have the determination to test this approach and eventually to modify it, if need be. Once the spirit of the new approach is clearly understood and imbibed, I am sure, no sincere teacher can resist trying it on his own initiative even with the limited resources in one's school.

Challenge to evolve better and more effective methods is there. Shall we or shall we not accept it?

EXTRACTS FROM APPENDIX 'D' OF THE REPORT OF THE DIRECTOR, SUMMER INSTITUTE IN CHEMISTRY, JAIPUR

It was felt that most of the experiments in the 'Laboratory Manual' could be covered by the students of Higher Secondary classes in the following manner:

CLASS IX	*CLASS X*	*CLASS XI*
Exp. 1: Scientific observation and description.	*Exp.* 7: The behaviour of solid copper immersed in a water solution of the compound $AgNO_3$.	*Exp.* 10: An investigation of the reaction volume of two solutions.
Exp. 2: Behaviour of solids on warming.	*Exp.* 9: Investigation of the reaction of a metal with HCl.	*Exp.* 14: A study of reaction rates.
Exp. 3: The melting temperature of pure substances.	*Exp.* 11: Reactions between ions in organic solution.	*Exp.* 6: Determination of solubility product constant of silver acetate.
Exp. 4 *and* 4*a*: Combustion of a candle and further investigations of a burning candle.	*Exp.* 13: The heat of reaction.	*Exp.* 18: Determination of H-ion concentration of solutions using indicators.
Exp. 12: A study of reaction.	*Exp.* 17: The heat of some acid-base reaction.	*Exp.* 19: Applying Le Chatelier's principle to some reversible reactions.
Appendix 2: Working with glass.	*Exp.* 20: An introduction to oxidation reduction.	*Exp.* 23: Quantitative titration.
	Exp. 22: Reactions between ions in solution.	*Exp.* 33 *to* 36: Qualitative analysis.
	Exp. 38: Some investigations into the corrosion of iron.	

It is suggested that the following demonstrations can easily be utilized by teachers at suitable places in day-to-day teaching:

1. Crystal structure — Experiment No. 27.

2. Atomic structure electro-valency, covalency coordinate valency	Using clay balls, iron rings etc.
3. Molecular weight	Victor Meyer's Experiment
4. Electrolysis of water, copper sulphate, etc.	Exp. 21.
5. Diffusion	Diffusion apparatus
6. Catalysis	Exp. 12 Part III
7. Heat of reaction	Exp. 13
8. Ionisation	(i) Exp. 21 (flow of ions in the salt bridge can also be demonstrated) (ii) Conductivity demonstration experiment (page 157 Teacher's Guide).
9. Study of reaction rates	Exp. 14.

Note: All the above experiments 27, 21, 12, 13 refer to the Laboratory Manual.

Teaching of Theoretical Concepts

Practical work by the students in the laboratory, demonstration by the teacher in the classroom, film shows and group discussion if properly coordinated will help build sound fundamental concepts in chemistry. It was felt that the CHEM-Study, material films if dubbed in Hindi can be profitably used in our schools. It was strongly felt that some of the new concepts such as molar concentration, uncertainty factor in measurements, oxidation number, etc. should surely be introduced at the school level. Also whenever a resourceful teacher feels confident, he can encourage students to take up projects with a spirit of research.

On close examination of the textbook *Chemistry—An Experimental Science*, it was realized that some of its material contents would be beyond the grasp of our students. Students are not at present brought to that level of understanding in Class VIII and subsequent classes so as to fully grasp all the material. It was concluded that the approach followed in the following chapters and articles can be accepted in our present set-up also.

Chapter	*Name of the Chapter*
1. *Chemistry—An Experimental Science*	Articles 1 & 2 dealing with uncertainty in science.
2. Atomic theory	Mole concept & problems relating with it.
3. Chemical reaction	Underlying broad principles.
4. Kinetic theory	Only article 1·3 dealing with Avogadro's Hypothesis. Art. 2·1 dealing with gas pressure Art 2·2 concerning partial pressure and Art 2·4 pertaining to absolute temperature.

Chapter	Name of the Chapter
5. Liquids and solids condensed phases	From articles 1·1 to 2·6 dealing broadly with different phases, term solubility etc.
9. Equilibrium in chemical reactions	Only article 1·2 dealing with dynamic nature of equilibria.
11. Aqueous acids and bases	Articles 2, 3·3, 3·4 dealing largely with properties of acids and bases, their explanation, broad principles about conjugate acid and conjugate base and hydrogen ion in the proton transfer theory of acids.
13. Chemical calculations	Manufacturing of sulphuric acid on new lines.
14. Why we believe in atoms	Only article 1 dealing with laws of chemical combinations.

The following is the suggested list of those topics which do not come under the purview of many of our present syllabi, but need of which was deeply felt and it is suggested that they should be included in the syllabi at an early date.

Chapter No.	Name of the Chapter	Suggestive material
1	2	3
6.	Structure of atom and the Periodic Table	Articles 2, 3 & 4 dealing with Periodic Table, halogens, alkali metals and inert gases.
7.	Energy effects in chemical reactions	Whole chapter
8.	The rate of chemical reactions	Only article 8 1 concerning factors influencing reaction rates.
9.	Equilibrium in chemical reaction	Only article 1.7 dealing with application of equilibrium principles Haber's process.
10.	Solubility equilibria	Article 2 dealing with aqueous solutions, electrolytes.
11.	Aqueous acids and bases	Article I dealing with strong and weak electrolytes, idea of Kw.
12.	Oxidation-reduction reactions	Whole Chapter with reference to Oxidation numbers.
15.	Electrons and the Periodic Table	Article 1.5—1.6 particularly dealing with the hydrogen atom and quantum numbers with reference to orbital concept.
16.	Molecules in the gas phase	Articles 1 & 2 dealing with Banding Capacity of I and II raw elements.

1	2	3
18.	The chemistry of carbon compounds	Entire chapter with reference to new methods of determining empirical and molecular formula.
19.	The halogens	Whole of the chapter except article 1.2 dealing with ionic radii.

'Quiz' type of tests should be frequently used as a tool to assess students' understanding of the subject. It will be helpful to the teacher also to evaluate his own teaching and adjust teaching according to the requirements of the students.

It is also suggested that on the first day of classes IX, X and XI the students should be exposed to some excitement or thrill. Experiments like combustion of a candle, black box, blue bottle, can be taken up in classes IX, X and XI respectively.

SUMMER INSTITUTES IN SCIENCE AND MATHEMATICS
JUNE 8 JULY 15, 1964

SOME INTERESTING FACTS

Over 625 higher secondary school and pre-university class science teachers were in the institutes studying the new programmes and new approaches to the teaching of their subject.

Of these 151 were in Biology, 150 in Chemistry and 162 in Physics and 164 in Mathematics.

60 university professors and lecturers were involved in the teaching of these new programmes on a full time basis and another 50 on a casual basis.

A similar number of college teachers of science and mathematics had a summer experience in institutes for college teachers. Altogether, more than 1500 teachers, lecturers, readers and professors have spent their entire summer vacation in improving their knowledge of, and ability to teach their field.

The persons of institutes in universities and colleges throughout India had an impact on the other teachers located in the centres. Some 80 institutes are tentatively proposed for the next summer, assuming that there will be 40 participants in each of these institutes and about 50 students will be taught by each of them, then 160,000 students will have improved instruction in sciences as a result of the institutes planned for 1965.

Perhaps the outstanding discovery of both the participants and faculty members is the extent to which they can live and work in an informal co-operative way—towards the common ends that they have as professional people. The university professors have discovered new colleagues in the secondary school teachers with whom they worked and the secondary school teachers have found that they have an important role to fill in the educative process. They have acquired a new dignity in keeping with the new stature assumed in the co-operative relations in the study of science and mathematics in a summer institute. There is an awakening as to the needs and possibilities in the teaching of the sciences.

News and notes

SCIENCE TALENT SEARCH

A STATISTICAL analysis of the data of Science Talent Search, 1964 revealed some interesting points. The selection ratio of the awardees has been maximum in the small territory of Delhi, in the State of Maharashtra and the territories of Goa and Pondichery while that for the certificates of merit has been maximum in the States of Madras and territories of Delhi and Manipur. It has been found that 79 per cent of the items of thought type and 48 per cent of factual type were found to be good as judged on the basis of the discriminative and difficulty values. Items on comparatively new areas to the secondary students, viz., astronomy, zoology, engineering, meteorology, history and philosophy of science, etc., were found to be more discriminating on the top and the bottom groups rather than the traditional areas of basic sciences. It indicates that the high achievers do get an opportunity of coming in direct contact with other branches of sciences which are not prescribed in the school curriculum. The frequency distribution of scores on the Science Aptitude Test, the Essay Paper, Project Report and the Interview indicates that the curves are mostly positively skewed.

Out of the total number of candidates who took the test, 17 per cent were called for interview on the basis of their results on theory tests. 29.38 per cent of the students from Delhi territory have entered into the merit list. One of the reasons why the Delhi students have fared better at the Science Talent Search Examination may be that these students have better library and laboratory facilities together with better methods of teaching, e.g. through films, television lessons, etc. A student who has topped in the whole country comes from a higher secondary school in Delhi territory and has scored 245 out of 300, i.e. 82 per cent.

The inter-correlations between the various sub-tests is low, which indicates that there is no overlapping of mental abilities and academic achievements as measured by the four different tools.

The chief feature of an analysis of items is that a maximum number of items are attributed to those branches of sciences with which the contestants are familiar through curricula coverage. The number of thought type items is 95 while that of factual type only 65. This is a healthy tendency indicating the test tried to measure the powers of critical thinking and reasoning

The overall statistical analysis of the 1964 data indicates that further research can be done on the Science Talent Search Scheme and some useful projects are being drawn up at the Department of Science Education.

GENERAL SCIENCE TEXTBOOK PANEL

The first meeting of the General Science Panel was held on September 25 and 26, 1964 in the Department of Science Edu-

cation, Delhi. The main task of the panel was the preparation of textbooks for higher secondary classes, laboratory guidebook for students and guidebook for teachers. Besides these the panel set itself the task of selection and preparation of films, charts, models and other aids; and the preparation of a short-term programme for training teachers.

It was also decided that the curriculum should include some laboratory work and demonstration.

The second meeting of the panel was held at the Saha Institute of Nuclear Physics, Calcutta from November 8-11, 1964. The concepts and sub-concepts for the units prepared by the members were discussed and modified. Experiments to be performed by the students individually or in groups along with the apparatus to be improvised were suggested. Some members also suggested projects to be undertaken with the units.

It was decided to compile the concepts and sub-concepts relating to the following units.

1. Meteorology.
2. Earth and its mysteries.
3. Natural wealth.
4. Human Body, Food and Wealth.
5. Matter and Energy.
6. Useful Materials.
7. Transport and Communication
8. The Universe.
9. Living Things
10. The Plants.
11. The Animals.
12. The Human Race.

BIOLOGY TEXTBOOK PANEL

The first Section of the book 'Biology A Textbook for Higher Secondary Schools' was published early in September, 1964. This section introduces the subject of Biology to the students, describes the variety of plant and animal life and generally prepares the pupil for a more detailed study in later sections.

Section 2 of the book is in the Press and will be released in January, 1965. This section in its fourteen chapters acquaints the readers with the diversity of plant life a little more closely. The plants which are more familiar were taken first. These are the seed plants (higher plants including anjiosperms and gymnosperms) which include trees found in the fields and forests and which provide mankind with the three basic necessities--food, shelter and clothing.

The panel is making every effort to bring out the other sections of the book in quick succession.

Books

For your science library

BIOLOGY: A Textbook for Higher Secondary Schools. Section 1. Some Basic Facts About Life. P. Maheshwari and Manohar Lal (ed.) National Council of Educational Research and Training, New Delhi, pp vii+100; Rs. 2.25. 1964.

THE National Council of Educational Research and Training has drawn up a programme of production of textbooks in various school subjects. Of particular interest to science teachers, is the work of the three panels in physics, chemistry and biology and that in mathematics. The Panel for biology is headed by Prof. P. Maheshwari, Head of the Department of Botany, Delhi University. The Panel has developed a curriculum for high school biology taking into account modern concepts of biology. The textbook prepared by them is based on this curriculum.

The Section 1 of the book that has now been published introduces the student to the variety of plant and animal life and prepares him for a more detailed study in the subsequent two sections. The fourth section simply outlines the main physiological processes in animals and plants. The fifth section is devoted to a comparative account of the modes of reproduction in plants and animals. Heredity evolution and ecology constitute the sixth section of the book. The last section covers topics like human diseases, interdependence of plants and animals, and the role of biology in human welfare.

A wide acquaintance with a number of different kinds of organisms, their activities, habits, tissues and organs, is essential to the understanding of the general concepts of evolution, ecology, heredity and cell physiology. This approach combines both the pedagogical advantage of proceeding from the known to the unknown, and also saves students from getting lost in the maze of sophisticated aspects of biology.

Section 1, the present release, introduces the students to the subject matter of science, particularly biology, and the characteristics of living matter. The first two chapters deal with general aspects of scientific method, scientific attitude and a historical account of how biological science developed. The third chapter tells the student how to distinguish the living from the non-living. The next three chapters describe the cell and its division, and the differentiation of cells into tissues. The last three chapters give a brief account of how plants and animals are classified into major plant and animal groups.

The book is written in a simple style and is profusely illustrated. This book has been prescribed by the Central Board of Secondary Education as a textbook for all schools affiliated to it in Delhi as well as other states from the current year 1964-65. The other schools, which

either teach biology as an elective science or as part of general science, will find this book very useful quite up-to-date and authentic. After all the sections are printed as paperbacks the whole volume will be brought out as one book.

S. DORAISWAMI

Teaching High School Science. A Source-book for the Biological Sciences. MORHOLT E., BRANDWEIN, P.F. and JOSEPH, A. Harcourt, Brace & World, Inc., New York. pp. ix 506, 1958.

THIS volume is one of a series of three books which deal with techniques, procedures, demonstrations, projects, experiments and suggestions for a teacher to use in classrooms. They have all been tested in classroom situations. They have been used to teach students of different levels of ability. The wide range of methods, activities and projects given enable a teacher to suit what he prefers according to his students.

While Section one is a general introduction of the usual laboratory techniques and procedures, Section two deals with techniques in the classroom. Different chapters deal with different biological processes each describing a number of experiments and activities. Section three gives special techniques in the study of anatomy of plants and animals, maintenance of cultures, care of animals in classroom, growing of plants and other science facilities like laboratories, green-house, school nature corner, museum, etc. Section four gives useful information under 'Teachers' references'.

The book will be very useful to any teacher of biology, particularly, when he is starting his career as the sole biology teacher in a school.

S. DORAISWAMI

The Amateur Scientist (Projects from the *Scientific American*) STONG, C.L. Heinemann, London 1921. pp. 584.

THIS book contains about 50 scientific projects which can be performed in the Science Clubs of the schools. These projects are taken from archaeology, biology, natural sciences, earth sciences, nuclear physics, mathematical machines, aerodynamics, optics, heat and electronics.

Most of these projects require simple, cheap and easily obtainable material and apparatus. Some of them are, how to cultivate harmless bacteria; an analytic technique-chromatography; electrozonephoresis, how to know rocks; how to track earth satellites, making of your own atom smasher, seismological observatory, mathematical computer, X-ray machine, etc. Though some of the projects like, transistorized drive for telescopes from astronomy; electronic seismograph, seismometer, etc. from earth sciences; spectrometer, etc. from nuclear physics; and puzzle circle from mathematical machines, etc. require a little higher knowledge to understand the scientific principles, these will initiate the young students to take up difficult projects with interest and courage and will make them acquire sufficient confidence. This will be a useful book for the Science Clubs.

K S. BHANDARI

How To Make A Home Nature Museum BROWN VINSON. Little Brown & Co., Boston. 1954. pp. 214.

THIS book shows how to plan and organize a museum on a small scale and how the little corner of a room either at home or at school can be converted into an interesting and exciting place by equipping it with the beautiful displays of the out-of-door world. How to collect specimens such as rocks and minerals, soils, chemicals, plants, fossils, insects and similar creatures, reptiles and amphibians, mammals, birds; and how these collections can be stored, classified, mounted and labelled, are some of the important features of this book. It also gives instructions on how to make casts or models of things that already exist, viz., animals and plants etc., from plaster of paris, rubber and wax moulds. One of its chapters also suggests the ways and means to use drawings, charts, diagrams, and paintings for the small nature museum. A list of some books, many of which may be useful for science clubs of the schools, is given at the end. This book will be useful in helping the organisation of the Science Club activities.

K.S. BHANDARI

Experiments in Applied Chemistry. (Third edition) STELLA GOOSTRAY & J. RAE SCHWENCK. The Macmillan Co. New York. Pp. 138, 1961.

THIS is a laboratory manual meant to accompany 'A Text Book of Chemistry' by the authors for students of nursing and home economics but it can be adapted with any other standard textbook in chemistry.

Besides the usual experiments covered in a chemistry practical course like laboratory techniques, physical and chemical changes, study of gases, kinetic molecular studies, energy and control of chemical changes, oxidation-reduction reactions, ionisation, acids, bases and salts, solutions and colloidal dispersions and qualitative tests of ions, there is a positive bias towards biochemistry. Starting with detection of elements in organic compounds and the study of reactions of typical organic compounds the student is led to food chemistry, elementary analysis of food constituents, urine, blood and bone. An elementary study of enzymatic action in digestion is also made.

The whole material is so arranged that it is possible to work the activities in a 30-hour, 40-hour or 60-hour course. Each chapter, consisting of a series of experiments, is organised under objectives, things needed, procedure and questions for discussion. The questions will help a lot of self study by the students.

Though this volume may not fit with the curricular pattern of the present day secondary school chemistry of our country, the experiments in chapters 15 to 19 introducing the student to biochemistry may provide motivation for co-curricular work and science club activity.

For the teacher, Appendix I dealing with preparation of stock solutions and special reagents and Appendix III dealing with removal stains will be informative.

N. K. SANYAL

Modern Chemistry. DULL C. E., METCALFE H.C. and WILLIAMS J.E. Holt, Rinehart and Winston, Inc. New York. Pp. 694, 1962

IN this revised edition of the older textbook in chemistry of the same name by the same authors for the secondary schools of U.S.A., the authors have brought the subject matter up-to-date and kept the modern approach to the teaching of chemistry in view.

There has been greater emphasis on fundamental physical concepts that explain the chemical processes and phenomena. The basic ideas of atomic structure, Periodic Table, chemical bonding and chemical equilibria are dealt with a modern view point. The concepts of sub-levels in atomic structure, electro-negativity in chemical bonding, the phenomena of periodicity of atomic radia and ionization potential, oxidation-reduction based on electron transfer and acid behaviour in terms of hydrogen ion are dealt with clearly Traditional descriptive chemistry has been minimised though sufficient material is included to cover the most essential substances and to develop the relationship of structure of substances with their properties.

The idea of atomic mass unit and a revised table of atomic weights based on C 12 has been given. The 13 tables in the appendix supply necessary physical data and log tables.

The text matter contains some starred sections meant only for the better students or for those who have to go for college preparation. The major portion, which is unstarred, caters to the average students and presents a complete course of chemistry.

Besides numerous line and wash drawings the text is suitably illustrated with many diagrammatic flow charts, over 140 actual photographs and four pages of coloured plates.

The organization of the textbook is helpful for the student as well as the teacher. Besides giving a summary of the contents and vocabulary, there are ample graded questions, numerical problems and suggestions for further activity. At the end is supplied a glossary which is particularly helpful for the students.

N. K. SANYAL

Regd. No. R. N. 7455 63.

INSTRUCTIONS TO AUTHORS

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